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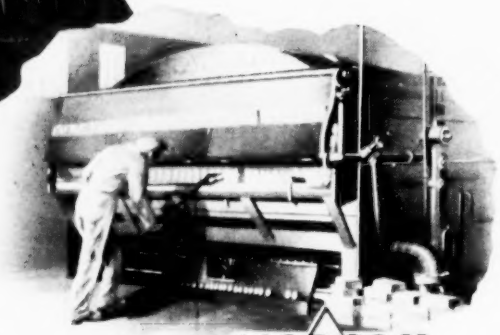

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CERAMICS

DECEMBER, 1952

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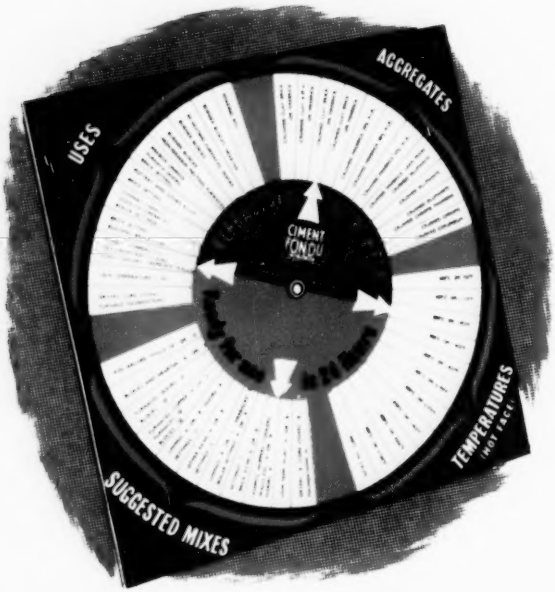

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Ceramics

VOL. IV DECEMBER, 1952 NO. 46

FUEL ECONOMIST

THE publishers of this journal have decided to extend their scope in the field of technical publications to include a new journal with the title *Fuel Economist*. Recently, in the editorial to the first edition, the policy of the new journal was laid down as follows:

1. The paper accepts that nationalisation, in one form or another, of the coal, electricity, and gas industries, is a *fait accompli*, and that their return to private enterprise conditions as known prior to 1939 will not take place in this generation. Assuming this true, the necessary transition will be from nationalisation as it is now understood towards an integration of the industries, each maintaining its autonomy within an integrated policy.

2. *Fuel Economist* believes it is unhealthy for the nation that there should be bitter competition (as at present understood by the word) between these industries and it is vitally important that they work together as harmoniously as possible in the interest of the nation. Of course, human nature being such as it is, there will be a healthy form of competition between the three, but *Fuel Economist* would rather that the competition was to be compared with the respective "houses" at a school, whose separate interests, in the end, are merged to the ultimate benefit of the whole school itself when the occasion arises.

3. *Fuel Economist* accepts that the fundamental consideration of the three nationalised industries is not towards these industries themselves, but the community in general.

Out of these axioms come the considerations which will bring about a desirable state of affairs in Britain in so far as fuel is concerned:

(i) A tremendous problem lies ahead in educating the consumer of the real need for economy in fuel utilisation and, simultaneously, how this can be achieved.

(ii) *Fuel Economist* will see to it that the consumer is adequately informed on every aspect of ideas or equipment leading to this essential end.

(iii) *Fuel Economist* will ensure that local authorities, parliamentarians, economists, fuel engineers, and distributors of

fuel appliances are accurately informed on matters appertaining to the improved utilisation of fuel.

(iv) Britain has one indigenous source of chemicals and energy. It is coal. Germany built a chemical economy on coal during World War II. No other industrial nation wastes the potential energy in coal to the extent that happens in Britain. And Britain cannot afford much longer to waste its cheapest raw material.

A few points at random can be selected. Solid fuel room-heating appliances of more than 40 per cent. efficiency must be encouraged; the production of high-efficiency open fires of the utility type capable of easy installation into existing fire openings, and with convection heat and a restricted throat, are important. Production of simple devices to insert into existing flues to restrict the chimney throat will show immediate dividends.

Particular stress will be laid upon the advantages of correct insulation for domestic premises and factories. *Fuel Economist* will agitate for real financial incentives to those who install efficient fuel appliances and use adequate insulation. The paper will provide advice on fuel efficiency.

But, above all, *Fuel Economist* will seek to keep the responsibility for producing and manufacturing gas, electricity, and coal in the hands of the present managers and oppose most rigorously the suggestion of the Ridley Report that an external authority such as a national planning committee or an external tariffs advisory committee, having authority without responsibility, should be saddled upon the present managers of the fuel industries.

The first issue of *Fuel Economist* is being distributed with a number of copies in excess of 7,000. Among its readers will include gas and electrical engineers and Coal Board officials. It will be seen by retailers of solid fuel appliances—by the gas showrooms—by ironmongers—by architects and local authorities—by members of the various fuel consultative committees up and down the country—by manufacturers and progressive lay opinion.

Fuel Economist welcomes comment from all sources, providing there is real interest in fuel conservation. It will report the fuel discussions in Parliament and at Consultative Council level. It will describe steps which can be taken in fuel economy now.

In short, it will live up to its title of *Fuel Economist* with a clearly defined editorial policy directed at a clearly defined readership which, on the first issue, will amount to at least 30,000 people all interested in shaking fuel policy free from dogma.

Fuel Economist will constructively criticise towards placing fuel economics in correct perspective as a vital tool to British economy, which means better living standards.

Everything must begin some place—*Fuel Economist* has sixteen pages for its first issue, but unbiased and informed opinion tell us that a truly independent paper of fuel economics grinding neither the axe of a Government department nor that of a particular fuel industry is very much needed. The Editor seeks the support and co-operation of all interested in this worthy theme.

There is no doubt that in the ceramic field the importance of the correct utilisation of fuel is very real indeed. It is witnessed by a very active fuel society where there have been some very useful contributions covering fuel technology in the pottery trades. It is hoped that arrangements can be made for the meetings of the local fuel society to be adequately reported in the pages of *Fuel Economist*.

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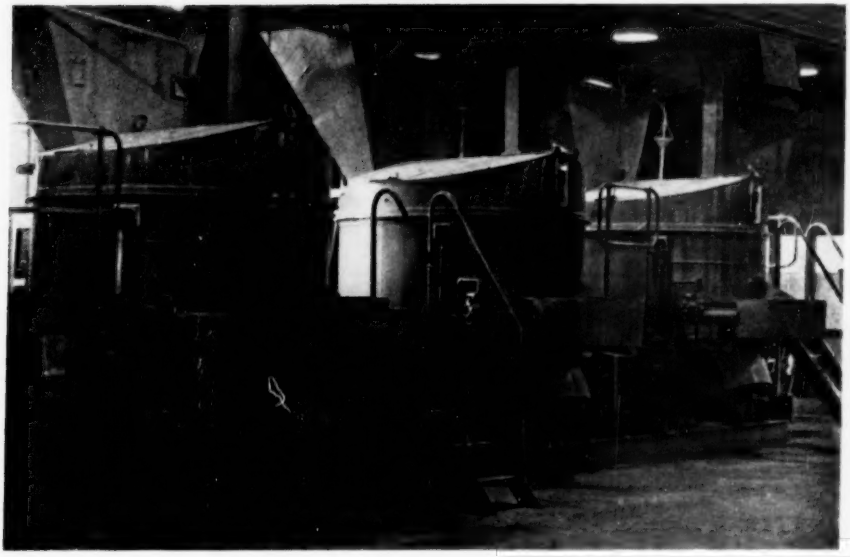

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THERMOSCOPES AND THEIR APPLICATIONS

By

W. J. GERMAN, M.Sc., Ph.D., F.R.I.C.

In most ceramic processes we are concerned with a continuous variable which is certain to vary during the process. Unless the process is already well established, for example when we fire the kiln to a certain size of cone, it is useful to know certain points. Knowledge of therefore will questions as the course of chemical reaction. The desired result can be achieved by firing at one temperature for a certain time, or by using a higher one for a shorter time. The effect of temperature alone is often referred to as "heat work" and this can be done in a short time at a shorter or longer time within limits by altering the temperature. The product is added since it is only when varying the temperature that heat is difficult such a blowing of the ware.

The heat work done on a body can be controlled by noting the over temperature and the duration of firing, but where there are temperature variations in the oven it would be difficult to assess the heat work at different parts without either a large number of pyrometers fixed all over the oven (which for many reasons would be impracticable) or the aid of some simple heat-work recorder.

Wedgwood's "Bits"

Modern temperature recording devices were not available to the early potters, and it is therefore not surprising that they evolved simple means of following the progress of firing. Simple types of pyrometric cone are said to have been used by the Chinese.

In our own country Josiah Wedgwood used small cylinders made first of stone and whiting, and later of clay and flint, to follow the firing of his ovens. The "bits" were fired with the ware, and their contraction measured by dropping them into a slot formed by two pieces of metal, one of which was engraved with a scale (Fig. 1). The higher the contraction the farther the bit dropped into the slot.

Such an instrument was cheap and easy to use. The "bits" could also be preserved as a record of the firing. This instrument is not used nowadays, though the underlying principle survives in modern contraction rings.

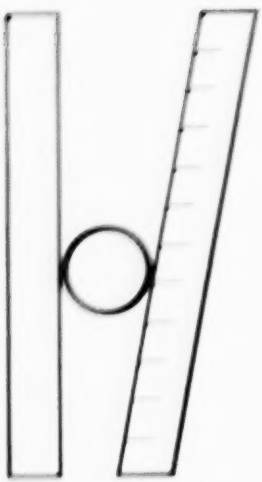
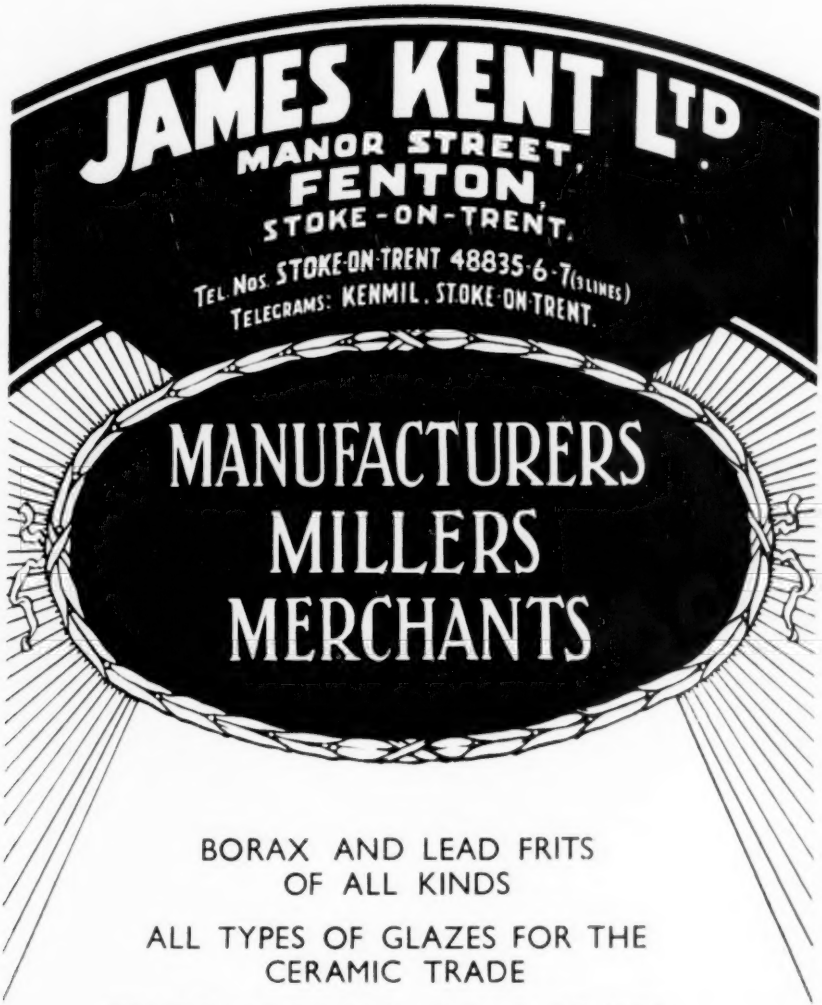


Fig. 1

Types of Thermoscope

Thermoscopes, or heat-work recorders, can be divided into two types:

(a) those which depend on



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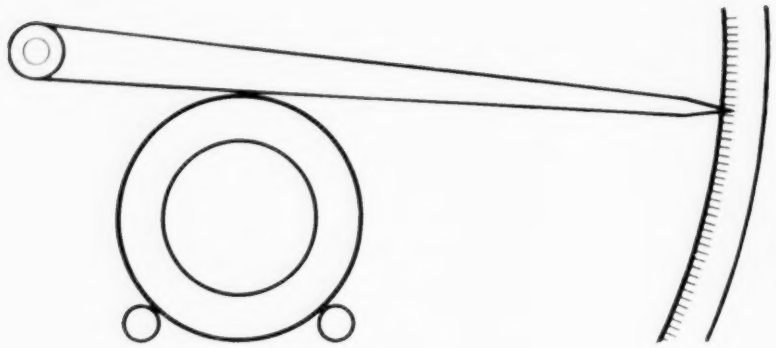

Fig. 2

shrinkage and (b) those which depend on the fusion of mixtures of ceramic materials.

The first type is exemplified by the contraction rings made in this country by Bullers Ltd. of Hanley, Stoke-on-Trent, and known as Bullers' Rings. The use of these has been described in some detail in the September 1952 issue of this journal, and only a brief description will be given here.

They have the advantages of being easily withdrawn from the oven during firing by a poker with a hook at the end, and can be preserved as a record of the firing of the oven if required. The ease of withdrawal is important, as it is not easy to follow the behaviour of thermoscopes with the eye in a hot oven and, unless they can be removed, they serve only a post-mortem purpose.

The rings are measured after use in a special gauge in which the ring is held on two metal stops and a hinged lever rests on the top of it, the end of which indicates the ring number on a scale (Fig. 2).

Contraction Rings Dust-pressed

For reliable and consistent results certain conditions must be observed. The rings are dust-pressed from a body of the porcelain type, and stringent control is required, and is in fact given by the manufacturers, to all stages of the process. This involves controlling the composition and grain size of the raw materials, and the conditions of pressing. Certain vegetables dyes are added for identification purposes to the different types of ring which are made.

In addition to the original ring (No. 27, coloured green) there are now the following types available:

(a) No. 72 (uncoloured) recommended for use from 960° C. to 1,310° C. (the green No. 27 is limited to 1,275° C.).

(2) No. 55 (brown). These can be used between 960° C. and 1,200° C., and have a rapid shrinkage between 1,000° C. and 1,100° C., and are useful for glost kilns and common brick kilns.

(3) No. 26 (pink) recommended for kilns operating up to 1,400° C.

The user must observe certain precautions if the contraction is to be a true measure of the heat-work done. Most important is that the firing shall be regular and not "flashy." Reducing atmospheres do not appear to affect the results given by the rings provided the atmosphere has been oxidising up to about 850° C.

Occasional accidental reducing, followed by oxidising conditions, do not impair the accuracy of the rings.

Only Approximate Temperatures

It is often stated that a ring contraction is equivalent to a certain temperature. This is not strictly true, and the makers state clearly that temperature indications are only approximate. This follows from the fundamental concept of the thermo-

TABLE 1
APPROXIMATE TEMPERATURES CORRESPONDING TO BULLERS' RING TRIALS

Temperature °C.	*Low Temperature No. 55 Ring (brown)*	*Standard No. 27 Ring (green)*	*High Temperature No. 72 Ring (uncoloured)*
960	3	0	0
970	7	1	1
980	11	2¼	2
990	15	4	3
1000	18	5½	4
10	21	7	5
20	24	8½	6
30	27	10	7
40	30	11½	8½
50	32	13	10
60	34	14	11
70	36	15½	12½
80	37	17	14
90	38	18½	15½
1100	39	20	17
10	40	21¼	18½
20	41	23	20
30	42	24½	21
40	43	26	22
50	44	27	23
1160	45	28½	24½
70	46	30	26
80	47	31¼	27
90	48	30	28
1200	49	34½	29
10	50	36	30
20	—	37½	31
30	—	38½	32
40	—	40	33
50	—	41½	34½
60	—	43	37
70	—	44½	38½
80	—	46	40
90	—	47	42
1300	—	48	44
10	—	—	46
20	—	—	47

scope, namely that it measures heat work, and the latter may be done by different temperatures, with corresponding alterations of soaking time. Pyrometer and thermoscope readings therefore seldom agree exactly.

Bearing this in mind, an approximate indication of the temperature can be obtained with the green rings by a formula:

$t°\,C. = 960 + 7 \times$ ring number

For other types of ring the approximate temperatures are given in Table 1. These are arrived at by using a rate of heating similar to that of a normal firing cycle, and for other rates of heating should be adopted with caution. The rings do not contract below 960° C., in fact they may expand over the range where dehydration of the clay molecule occurs.

Pyrometric Cones

Thermoscopes depending on squatting or bending are exemplified by Seger cones and Holdcroft bars. Watkins recorders are fusible plugs of material set in refractory holders. Fusible cones have been ascribed to Louth and Voght (*Bull Soc. Chim.* **46,** 786, 1886, c.f. Burgess and Le Chatelier "High Temperature Measurements" p. 368, 1912, also C. O. Fairchild and M. F. Peters. *J. Amer. Ceram Soc.* **9**, 701, 1926).

Cones were used by the potters at Sévres about 1884, but it was not until Seger published his series of

TABLE 2

SEGER CONES		APPROXIMATE SQUATTING TEMPERATURES			
Cone No.	°C.	*Cone No.*	°C.	*Cone No.*	°C.
022	600	1a	1100	28	1630
021	650	2a	1120	29	1650
020	670	3a	1140	30	1670
019	690	4a	1160	31	1690
018	710	5a	1180	32	1710
017	730	6a	1200	33	1730
016	750	7	1230	34	1750
015a	790	8	1250	35	1770
014a	815	9	1280	36	1790
013a	835	10	1300	37	1825
012a	855	11	1320	38	1850
011a	880	12	1350	39	1880
010a	900	13	1380	40	1920
09a	920	14	1410	41	1960
08a	940	15	1435	42	2000
07a	960	16	1460		
06a	980	17	1480		
05a	1000	18	1500		
04a	1020	19	1520		
03a	1040	20	1530		
02a	1060	26	1580		
01a	1080	27	1610		

cones in 1886 that there was a range available designed to give regular temperature increments between the consecutive cones (cf. Collected Works, *English Translation*, Easton Pa. 1902). This interval was 20° C. and No. 1 softened at about 1,150° C. and No. 36 at about 1,700° C.

Again, as with other types of thermoscope the temperature indications are only approximate, since it is the heat work done that brings about bending of the cones. This is illustrated by the fact that a china biscuit oven was fired up to Cone 10 down in three days, corresponding to a temperature of 1,300° C. (Table 2). Pyrometer readings showed that the oven had never been above 1,200° C. The explanation is simple. The temperatures given in Table 2 were those at which the cones squatted when soaked for two hours. The same heat work had been done in the kiln

TABLE 3

ORTON CONE VALUES

	Squatting Temperature			*Squatting Temperature*	
Cone No.	*20°C./hour rise*	*150°C./hour rise*	*Cone No.*	*20°C./hour rise*	*150°C./hour rise*
022	585	605	1	1125	1160
021	595	615	2	1135	1165
020	625	650	3	1145	1170
019	630	660	4	1165	1190
018	670	720	5	1180	1205
017	720	770	6	1190	1230
016	735	795	7	1210	1250
015	770	805	8	1225	1260
014	795	830	9	1250	1285
013	825	860	10	1260	1305
012	840	875	11	1285	1325
011	875	905	12	1310	1335
010	890	895	13	1350	1350
09	930	930	14	1390	1400
08	945	950	15	1410	1435
07	975	990	16	1450	1465
06	1005	1015	17	1465	1475
05	1030	1040	18	1485	1490
04	1050	1060	19	1515	1520
03	1080	1115	20	1520	1530
02	1095	1125			
01	1110	1145			

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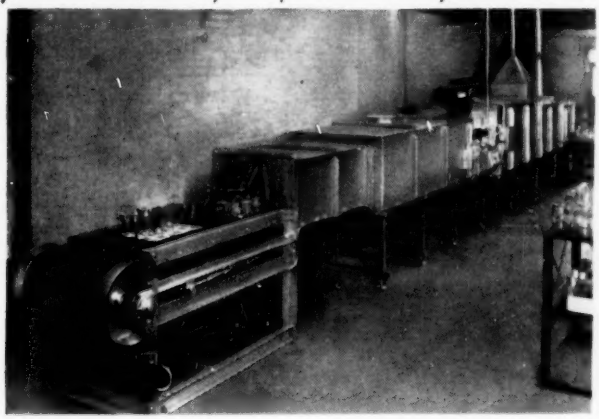

(Left.) Glassware passing through 38' Electric Decorating Lehr. (Photo by courtesy of A. & I. Friedman Ltd.)

(Below.) Pottery being handled through Glost and Decorating Furnace. (Photo by courtesy of John Tams Ltd.)

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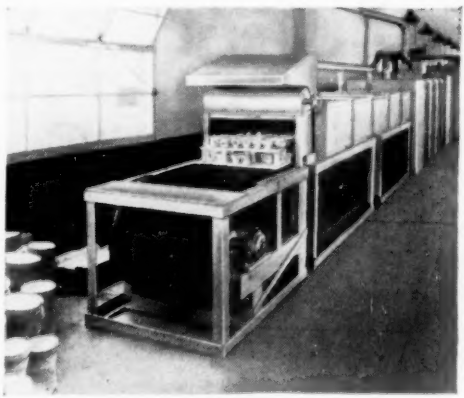

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TABLE 3—*continued*

Squatting Temperature			*Squatting Temperature*	
Cone No.	100° C./hour	*Cone No.*	600° C./hour	100° C./hour
23	1580			
26	1595	34	1755	1760
27	1605	35	1775	1785
28	1615	36	1810	1810
29	1640	37	1830	1820
30	1650	38	1850	1835
31	1680	39	1865	—
32	1700	40	1885	—
33	1745	41	1970	—
		42	2015	—

over the longer period of 72 hr. at a much lower temperature.

The Seger cones were manufactured by the Prussian Government at Charlottenburg and were very useful, so much so that successful attempts were made to extend their range. Thus Cramer made a series of cones melting at lower temperatures than Cone 1. These were labelled Cone 01, etc., to avoid disturbing the original cone numbers which were well known.

The Seger cones were improved by Hecht (Tonind Zeit. 1892, 1895) and Simonis (Sprech. **41**, 561, 1908). The former added cones 40-42, while the latter recommended the omission of cones 21-25 as the temperature difference between them was only 50° C., and the abolition of lead and iron oxides from cones 021 to 6, since these were affected by reducing gases. These cones were replaced with the "a" series. Revised compositions of the German cones are given by Dr. Felix Singer "Ceramic Glazes," Borax Consolidated Ltd., London, 1947. Details of other cones are not published, though they are probably similar to the German type. The ingredients used are commonly kaolin, felspar, quartz, marble, and magnesite.

Orton Cones

In America Orton cones are used. These are used in the same way as other cones and the temperature relationship corresponding to different rates of heating is given in Table 3 cf. C. O. Fairchild and M. F. Peters (loc. cit.).

The relationship between the softening points of German, French, English and American cones has been determined using comparable heating rates (50° C./hour to within 300° C. of squatting temperature and then 20° C./hour till test completed) by R. F. Geller and E. E. Pressler (*ibid* **9**, 744, 1926). Similar comparisons have been made S. S. Coles (*ibid* **8**, 462, 1925) on English and Orton cones.

Staffordshire Cones

The cones used in this country were developed during the 1914-18 war by the late Dr. W. J. Mellar at the North Staffordshire Technical

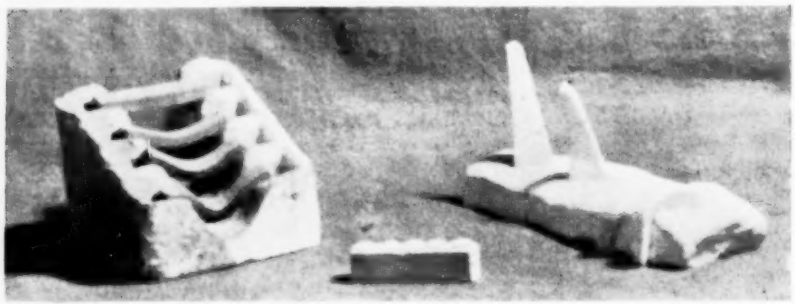

Fig. 3

College, when supplies of German cones were cut off. Their manufacture at the College was discontinued in 1937, and has since been carried on by Harrison and Son Ltd., of Hanley, Stoke-on-Trent. In addition to the original Staffordshire cones this firm now supply a new H series of Staffordshire cone, which is the result of a restandardisation.

In this new series the restandardisation has made possible for those who require them, intermediate cones. To avoid confusion the letter "a" on Cone 015a to 6a has been dropped, and a capital "A" introduced to designate the new intermediate cones. Thus Cone H07A melts intermediately between Cones H07 and H06 and Cone H6A between Cones H6 and H7. To bridge the gap between 1,250° C. and 1,280° C. there are now two cones H8A and H8B. These intermediate A cones make possible a 10° C. interval between cones, and are available between Cones H07 and H11 in the first instance though others could be provided if required.

As with all other series of cones the temperatures are only exact if the rate of heating is the same as that used in standardising the cones. The approx. squatting temperatures of the H cones are the same as those given in Table II, e.g., Cone H07 corresponds to Cone 07a in the original series.

Use of Cones

The cones are set up on a refractory base of clay or some other suitable material, depending on the temperature expected. They should not be put in the oven on a wet clay base, which will disintegrate due to eruptions of steam, but the base should be dried first. The cones are usually inserted about ½ in. into the base, or if this is not possible they can be fastened on with a little plastic refractory clay and dried. They must not be deeply embedded or the freedom to bend over may be impaired. The cone should bend over in a smooth curve till the tip touches the refractory base. Any sharp bend probably indicates that the cone has been knocked accidentally by, for example, a poker, or that it has cracked.

Very sharp fire will bring down cones prematurely, and reducing atmospheres, especially those containing sulphur gases, tend to build up a crust of carbon and sulphates on the outside of the cone. Cases have been known where this has remained standing when the fluxes have run out at the base.

The usual method of use is to mount together a series of cones covering the expected temperature range. They are placed with the numbered face at the angle to the vertical provided by the shape of the cone (15° with Staffordshire H cones). The fireman is given warning of the approach of the required conditions by the collapse of the softer cones (Fig. 3).

The following cones are recommended for the uses given. The numbers refer to the H cones on which the "a" on the older series is dropped as explained above.

Glass colours	022 to 016
Enamel kiln (soft)	019 to 015
do. (ordinary	014 to 011
do. (hard)	012 to 07
Red brick kiln	010 to 01
Tile glost and majolica kilns	07 to 01
Glost oven (soft glazes, Rockingham)	05 to 1
do. (e'ware and china)	03 to 5
E'ware biscuit	3 to 8
Vitreous tile and granite biscuit	4 to 9
China biscuit and sanitary ovens	7 to 12
Hard Porcelain	13 to 17
Fire and silica bricks	7 to 15
Special refractories	17 & over
Refractoriness tests	26 & over

Holdcroft's Bars

These are a dust pressed article, and can be used for similar purposes to cones. They are supported horizontally on a special refractory holder, and bend as a result of heat work done on them.

Being supported at both ends they tend to bend more sharply than cones. Like cones they need protection from draughts of cold air, and contact with flames. The approximate bending temperatures are given in Table 4. These of course can vary with the rate of heating as explained with cones.

TABLE 4

APPROXIMATE BENDING TEMPERATURES OF HOLDCROFT'S BARS (°C.)

Bar No.	°C.	*Bar No.*	°C.	*Bar No.*	°C.	*Bar No.*	°C.
1	600	11	890	22	1080	30	1325
2	650	12	905	23	1100	31	1350
3	670	13	920	24	1120	32	1380
4	700	14	935	25	1140	33	1430
5	730	15	950	25a	1170	34	1460
6	760	16	960	26	1200	35	1475
7	790	17	970	26a	1230	36	1490
7a	810	18	985	27	1250	37	1505
8	840	19	1000	27a	1270	38	1520
9	860	20	1040	28	1280	39	1535
10	875	21	1060	29	1300	40	1550

The bars recommended for various purposes are as follows:

Enamel kilns	4—8
Hard kilns	8—12
Majolica glaze kilns	15—20
E'ware and china glost	20—24
E'ware biscuit	24—28
China biscuit	28—32
Red brick and roofing tiles	20—24
Vitreous floor tile biscuit	25—29
Blue bricks	24—28
Fire bricks	25—30
Hard paste porcelain	30—40

Watkins' Recorders

These are a series of numbered pellets which are made up in sets in small refractory blocks. The pellets are sealed in the blocks by paper bands and the whole can be taken straight from the box and placed in the oven without any further preparation, as the paper fires away. They are made by Henry Watkin of Burslem, Stoke-on-Trent. The recorders cover various temperature ranges, and after firing, the pellets which have fused are held in the block and the others can be tipped out. The fusion of the pellets is brought about by heat work done on them, and the approximate temperatures at which this happens is given in Table 5.

In conclusion it should be stated that most manufacturers regard pyrometers and pyroscopes as complementary. The former are used to regulate oven conditions generally, while the latter are used to indicate conditions at particular points in the setting where temperature measurement would be difficult or impossible. In this sense the fact that pyroscopes indicate heat work, and not exact temperature, is an advantage rather than otherwise.

TABLE 5

SOFTENING TEMPERATURES FOR WATKIN'S RECORDERS

No.	°C.	*No.*	°C.	*No.*	°C.
1	600	24	1120	47	1670
2	650	25	1140	48	1690
3	670	26	1160	49	1710
4	690	27	1180	50	1730
5	710	28	1200	51	1750
6	730	29	1230	52	1770
7	750	30	1250	53	1790
8	790	31	1280	54	1825
9	815	32	1300	55	1850
10	835	33	1320	56	1880
11	855	34	1350	57	1920
12	880	35	1380	58	1960
13	900	36	1410	59	2000
14	920	37	1435		
15	940	38	1460		
16	960	39	1480		
17	980	40	1500		
18	1000	41	1520		
19	1020	42	1530		
20	1040	43	1580		
21	1060	44	1610		
22	1080	45	1630		
23	1100	46	1650		

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TBW217

DECORATING GLASS AND POTTERY

by

L. DUBUIT

Ingenieur E.P.C.I., Licencie es Science

Metallic Decoration

BY the screen process, it is possible to decorate glass, pottery or china in gold, silver or platinum.

The screens must be made of ordinary silk, firstly because bronze mesh may alter the very special enamels used, and above all because silk screens do not give such a heavy deposit of ink as metal screens. As a general rule, in metallic decoration with gold, silver or platinum, it is advisable to use as little ink as possible, and moreover, it is well known that a heavy deposit, instead of increasing the brilliancy, will, on the contrary, give a dull effect.

The products used should have the same properties as the colours when mixing enamels. The screens should be considerably larger than the design so as to lose as little as possible of these products, which are extremely expensive.

The designs obtained will be as fine and as clear as when using ordinary enamels for glass.

When using these products, should a misprint occur, care must be taken to thoroughly clean the article before reprinting, as the slightest trace left will appear during the baking. With regard to the latter, this should always be done in an atmosphere containing plenty of oxygen; in fact, many users go so far as to introduce air specially, or better still, oxygen, into the oven, as this ensures a gold of great brilliance.

Screen printing allows perfect grading, as the mixing of the two shades is done in an intimate and gradual way, which is completely impossible by any other process. Nevertheless, it will be obvious that the enamels used must be of a similar nature and fusability, otherwise difficulties will be experienced.

Half-tone Designs

In a general way, all line designs lend themselves remarkably well to reproduction by the screen process. It is also possible to reproduce half-tone effects, as in other printing methods, but this process calls for a great deal of skill.

Care should be exercised in the selection of the screen negative or positive of the design to be reproduced, and also in the choice of the weave forming the silk screen. If too fine a negative (or positive) is produced, there is a risk that the little dots will fall across the stitches of the silk mesh and disappear. If, on the contrary, the screen negative (or positive) is too coarse, the result will only be recognisable when seen from a distance.

In addition, the great difficulty which all process engravers know well is encountered, that is to say, a moire effect. This is regular and geometrical designs which are formed under certain conditions when two similar half-tone screens are super-imposed. However, if these two screens are moved in relation one to the other, this effect will almost completely disappear in certain positions.

In order to avoid this phenomenon, great experience is necessary. How-

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An extract from a paper presented on 17th June, 1952, to a meeting of pottery and glass manufacturers at the "Maison de la Chimie," Paris. Translated by E. A. Kuffall (London agent, Dubuit Machines, Park Avenue, Twyford, London, N.W.10).

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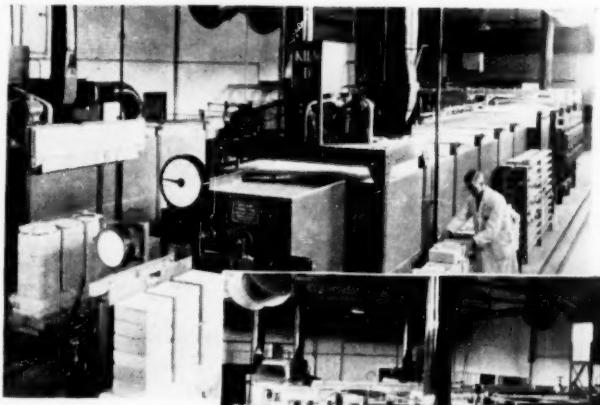

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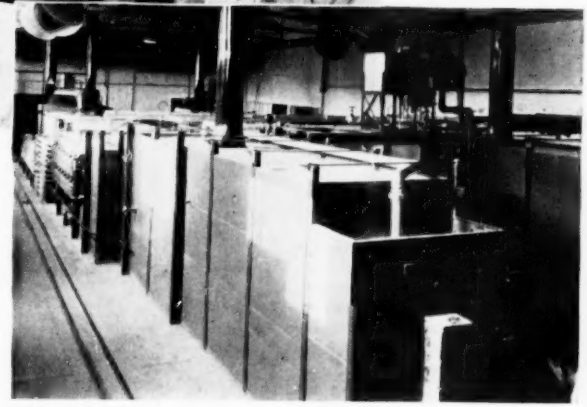

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ever, it can be said that the moire effect is avoided when the lines of the two screens, that of the proof, and that of the silk, form between them an angle of about 30°.

This result can either be obtained by stretching the silk in bias on the frame, or by asking the process engraver to reproduce the screen positive or negative in such a way that its lines form an angle of 30° with the edge of the proof. Moreover, the copy of the photo on the silk weave will be perfect if the mesh of the silk is twice as fine as that of the half-tone screen. If this precaution is taken, it is almost certain that each little dot will fall on to one of the silk threads.

It is recommended for this type of printing to use a plain weave silk, rather than the other types, as the twists and knots in the threads nullify the reproduction of the little dots, and plain weave silks give much finer results.

On glass or on earthenware, over glaze, results are not improved owing to the fact that it is necessary to use a fatty solvent, and the ink does not dry immediately. Indeed, the little squares of enamel deposited on the article through the silk, run into each other to give a unified surface. In half-tone reproduction, it is the spacing of the dots, either near to each other or far apart, which gives the half-tone effect. We shall therefore have, on a dark screen, instead of dots near to each other, a completely black surface, and therefore a sharply contrasted print, passing from extreme blacks to much lighter shades. On the other hand, in printing on biscuit it is possible to obtain very interesting results. As we have seen, biscuit immediately absorbs the impression, and as the dots which are deposited are absorbed at once, they remain distinct one from the other, and this allows very good half-tone effects to be obtained.

Grinding.

There are several different ways of grinding.

Grinding in jars. The easiest method consists in using jars made of porcelain, in which are placed marbles, also in porcelain, and the enamel and media to be ground. The jars are made to revolve for 24 hours, at the end of which time the product is ready for use.

All the same, this method has the inconvenience of introducing foreign bodies into the mixture, caused by the marbles rubbing against one another. Usually, this is not of great importance, as this does not harm the enamels. Moreover, it is possible to assess the quantity introduced by weighing the marbles before and after grinding. It also should be noted that this method, in taking 24 hours, causes the paste to thicken, and this does not give such good results as can be obtained by more rapid methods. It is for this reason that many users prefer to do their own grinding.

Grinding in cylinders. This method is generally to be recommended, as it gives satisfactory results.

Care must be taken to see that the cylinders do not get hot, and if necessary they should be cooled with water. These mixers generally consist of three cylinders of different diameters and lengths, according to the quantities required.

Flat Grinders. These are the best grinders, as they produce a very fine mixture. They consist of a flat slab, on which turn discs, usually made of glass, and which crush the colours exactly in the same way as an artist mixing his colours with a spatule.

Colours in Paste

These colours have been ground with the media in suitably adapted grinders, and the user can be certain of having no difficulty in employing these pastes. In order to conserve uniformity, these pastes are always supplied much thicker than their use necessitates, but there is no difficulty in diluting them just before use with a suitable quantity of the solvent. However, this quantity varies with each colour, and also with the coarseness of the mesh on the screen, and the fineness of the work required. The consistency of the colour is very important. A colour which is too liquid will have a tendency to spread and run, blocking the centres of small lettering, whilst a colour which is too thick will have difficulty in passing through the screen, and will not give

a smooth finish, and will lack brilliancy when fired. In general, basic colours should be thicker than the second or third colours.

We have seen that the screen process can replace nearly all other methods of decoration, and at a lower cost. But it must not be thought that it is sufficient to use the same enamels for this process to obtain the same colour. It is nearly always necessary whether printing on biscuit or over glaze, to make a series of tests to arrive at exactly that shade obtained by the other processes.

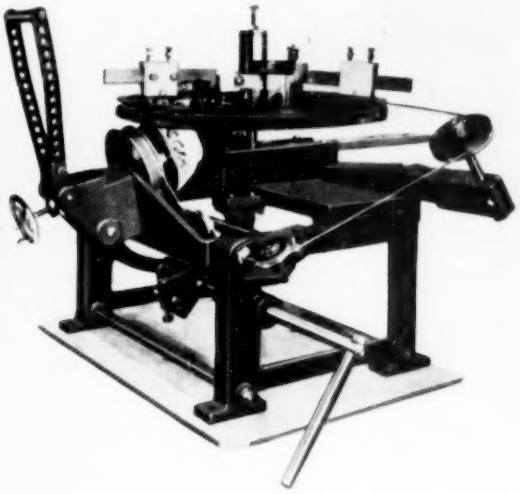
Decorating Shop

It is not our intention to say much on this subject, its lighting and ventilation, for these conditions vary considerably according to different shops. It is suggested that glass should be warmed before printing, and even better, should be left for about 24 hours before in the place where it is to be decorated. It is also recommended to make quite sure just before printing that the articles are absolutely dry, for the slightest trace of dampness on their surface will prevent a good result being obtained.

I would like to insist on a particular point which may come up in the course of the work, that is the cleaning of the underneath of the screen; care should be taken to ensure that the cleaning is absolutely perfect. To do this cleaning, a cotton rag soaked in solvent is used, and this should be repeated several times, to make certain that no trace of the enamel remains.

A dry cleaning, in particular, will very often leave traces of the enamel under the screen, which will later be deposited on the glass, and after firing this will give a blurred effect to the outline. Where several colours are used, traces of blue, for example, may give a blueish tinge to white enamel printed previously.

Very often, little holes appear in the screen, which spoil the design. These pin-holes should be stopped up with varnish, and the screen should be well cleaned underneath before applying a cellulose varnish. If this varnish is placed on a screen covered with colour a satisfactory result will not be obtained. The cleaning should be done with a light solvent, and never with a heavy one, such as turpentine.



Machine for printing bowls (Two colours, under glaze)

Drying Kiln

When printing in several colours, each colour must be dried after being printed. This drying is usually carried

out at a temperature of about 175°-200°. The drying is done on a metal chain with open links, similar to those used in conveyor belts or lehrs. The dryer is generally about 10 metres long, its width depending on the type of production needed.

The speed of the conveyor is about 0·50 m. to the minute, so that the article remains about 20 min. inside. Heating is by means of burners under the middle of the chain, which use gas, fuel oil, or any suitable medium, and the dryers are thermostatically controlled.

It is advisable to have fans at the end of the dryers, so that the article is quickly cooled down, and the second colour printed immediately. If, when printing the second colour, the first disappears, this is because it has not been sufficiently dried. The degree of dryness can be tested by rubbing with the finger; if the colour does not come off it is sufficiently dry, if on the other hand it does, it is not sufficiently dry. If on the contrary when printing the second colour, the first flakes off, it is too dry, and this flaking is rarely discernible before fusing.

After printing the second colour, the article should be once more passed through the dryer if there is a third colour.

Following the final colour, the article can be put straight on to the fusing lehr. Before this, however, each article should be carefully examined, because once it has been fused, if it is badly printed, it will certainly have to be rejected. In practice, before fusing, there should not be more than 4-5 per cent. of defective articles which can be cleaned off once dry.

These defects come from several causes (bad application of the second or third colour; contact of the bottles one against the other; too little ink on the screen; lack of care or of cleanliness). Whatever the cause, all bad prints should be cleaned off. There are three ways of doing this:

1. The dry method, by which the bottles are held against a metal brush turning at high speed, and which perfectly cleans the surface of the glass. The disadvantage of this method is that it creates a great deal of dust, formed from very poisonous substances having a lead base, and it is therefore only possible to use this method when wearing respirators, and when the workshop has been specially prepared.
2. The second method consists in cleaning the bottles with an appropriate solvent, such as "trichlorethylene." By rubbing the print with a rag dampened with this product, the articles can be cleaned. This second method is undoubtedly more expensive, but it is also much easier, and does not require special installations. It is suitable for small productions.
3. The bottles can be washed in a washing machine with a solution of caustic soda at 10 per cent., or a suitable detergent. The coat of enamel only fixed by the solvent easily comes off and forms a sediment at the bottom of the machine.

The Screen Process in Pottery

Decoration can be done either under or over glaze.

When decorating on biscuit, different enamels are used to those when the decoration is on glass or over glaze. Temperatures for firing are much higher (about 1,100°) than when the decoration is over glaze or on glass (about 800°). Because of this the range of colours is much smaller, especially for reds.

Once the decoration on the biscuit has been carried out, the articles are glazed, which is usually done in France by dipping. It is therefore necessary that the design should be pervious to the glaze, which must take equally well on the biscuit and on the print. This is the reason why articles which have been decorated by colours having an oily base, must be stoved at about 400° to burn out the grease, before they can be glazed. It is preferable when decorating on biscuit to use products which can be glazed directly, without it being necessary to burn out the oil. In this case the colours should be ground, not with a solvent, but with glycerine and water, although experience has shown that pure glycerine gives even better results.

Whether printing under or over glaze, the same machines are used. But when printing under glaze (especially on biscuit which is very porous, above 10 or 12° of porousness) the

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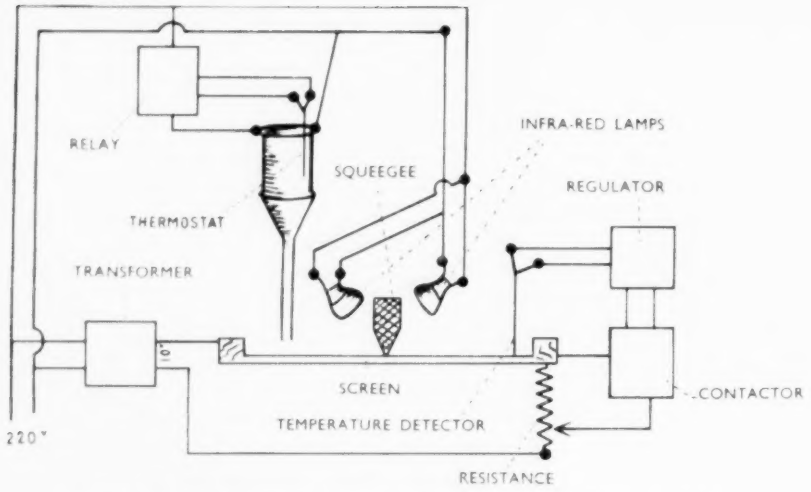


Wiring diagram for screen heating when using thermo-plastic enamels

biscuit immediately absorbs the ink, whether this has a glycerine or a water base.

In this particular case, the problem of drying has been solved, this problem being the bugbear of printers and glass decorators in several colours. In this particular case, it is possible to print the second colour immediately after the first, and so on.

This characteristic has allowed machines to be built whereby, for example, an ashtray in biscuit or an earthenware tile can be printed first in one colour, and then without moving the article, a second screen takes the place of the first one, and being mechanically operated, prints a second colour in perfect registration, and even a third colour, by means of a third screen. At the same time, the difficult question of registration is settled perfectly.

This has also permitted us to verify a point which up to now has been widely discussed; the influence of the direction of the squeegee in action on the registration. As the screens replaced themselves mechanically with perfect accuracy, we noticed that if ordinary silk was used, the direction of the squeegee in action could produce errors in registration from ½-1 mm. according to the tension of the screen. But on the other hand, if metal screens properly stretched were used, these slips became negligible, although they could still attain ½ mm. if the screen were slack.

From this, it was possible to build a whole range of machines, for flat objects, for cylindrical objects (cups), for conical objects (bowls, pots, etc.), and for plates, all with printing in several colours. For plates, machines fitted with a turntable system have been built, whereby the plate passes in succession under different screens, and is printed in different colours.

"Thermo-plastic" Enamels

As far as decoration on glass was concerned, no further progress had been made up to now, for printing in several colours, than that of printing the first colour, drying it in an oven, then replacing the object on the machine in registration, which is always difficult, then again drying it in the oven, and repeating the operation a third time for a third colour. To do this long and difficult work, the Americans have built machines which are real factories in themselves, whereby the bottles are placed horizontally on a machine where they are printed with the first colour; from there, automatically, they are placed on a chain or belt and passed through an oven for the first drying. They are then taken automatically on to another machine, then through a second oven,

etc. There is sometimes even a third machine and a third oven. It is true that these machines are real factories in themselves, are very expensive, and really only suitable for the American market.

Recently, however, the Americans have succeeded in producing what we call "Thermo-plastic" enamels. These are enamels which, instead of being ground with liquid solvents at an ordinary temperature, are mixed with plastic materials, waxes or resins, which are solid at ordinary temperature, but which melt at low temperature, for instance at 50°-100° C. If therefore these enamels are placed on a screen, and by some method are melted at their fusing point, as they become liquid it will be possible for the squeegee to pass them through the screen. As they are deposited on the object, the coldness of the glass will once more solidify them, thus bringing about immediate drying.

It can be seen that with the aid of this new discovery, the case will be the same as when printing on biscuit, namely, the impression will dry immediately. Under these circumstances it is possible to print several colours one directly after the other.

The introduction of these new enamels will thus revolutionise the whole technique of decoration on glass, and over-glaze in the case of earthenware and china.

These new enamels also bring other advantages. Up to now, it has been impossible to make a complete decoration around a bottle or glass, because when finishing the decoration, the beginning not being dry, smudged on the underneath of the screen. Now, since the decoration dries immediately, this has become possible, and hitherto impracticable designs can now be executed.

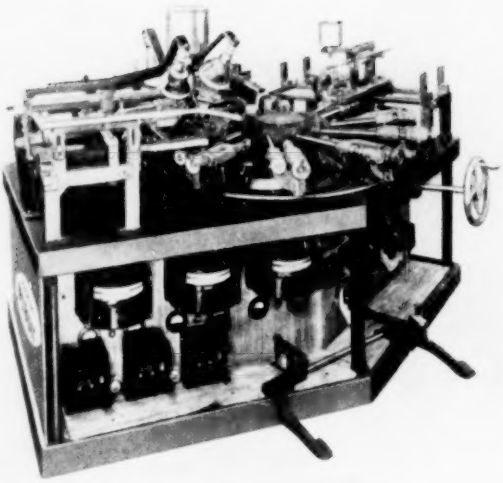
The use of these new enamels also makes very fine designs possible, as there is no tendency to spread, the print solidifying immediately, and having a much clearer definition. The colour does not dry whilst on the heated screen, and as there is no evaporation of the solvent, the consistency of the enamel remains constant, on condition of course that the temperature is itself constant. Another advantage is that these enamels do not clog the screen, and do not run through. There is also no enamel wasted as there are practically no misprints.

Thermo-plastic enamels fire exactly like ordinary enamels according to certain firms. According to others, they need to be "warmed up" longer. This would of course reduce the production of the lehrs. One of the disadvantages of these new enamels is that they have a tendency to absorb humidity, and in this case they call for a higher temperature to bring them to melting point.

There are several ways of heating the enamels, and in our opinion the best solution is to use the screen itself as an electrical element. If the screen is made of stainless steel, it is quite possible to insulate it and to put through it a low tension electric current, turning the screen into an electrical element which will melt the enamel. This method of heating has the advantage of bringing the heat exactly to the point where the enamel must be kept, although the screen has continuously got the cold contact of the bottles to be printed. In practice, this method of heating has not proved to be entirely satisfactory, and it has been necessary to add electrical elements on each side of the squeegee, which help to maintain the enamel at its correct fluidity by radiated heat. To complete the job, it has also been necessary to place electrical elements inside the squeegee handle.

Other methods have been tried and have given quite good results, such as using infra-red lamps.

Having found a way of heating the screen, it is also necessary to keep this heat constant. In America, this is done by automatic regulators, and we have turned to a more precise system of temperature regulators. The big difficulty is that thermostats cannot be used, as the temperature must remain as a precise point, and this has been overcome by using very precise thermo-couples which operate on a galvanometer, which acting by a relay, switches the heating on and off. Still higher precision is obtained in making these regulators operate on a shunt resistance, so that a continuous current gives a continuous flow of calories. It is the temperature regulator that controls the supply of current, when necessary, to keep the temperature to the chosen degree. As far as the machines are concerned, all those



Machine with turntable printing in three colours (3,000 completed pieces per hour) using thermo-plastic enamels

previously mentioned can be equipped with the necessary electrical heating, and in consequence we will have overcome the difficulty of registration.

The screen frames must be specially made. They must have the two short sides made of metal to enable the current to go through them, and the two large sides must be insulated. This insulation can be done by running an insulating tape between the metal mesh and the two large sides, but we have found it much more satisfactory to operate with special frames. These frames have the two small sides of metal, whilst the two large sides are made of triangular bars of fibre on which the mesh is fixed. A slot in the large face of the triangle allows of ensuring the correct stretching of the mesh by inserting an insulated bar.

For instance, if we have to print a bottle, this bottle will be placed on the machine between a chuck and a point, and will be made to revolve by the movement of the screen. In the first revolution, it will get the first colour, then, in the second revolution, the second colour will be printed, in the third revolution, the third colour, giving a very highly accurate registration. One difficulty however, still remains: the fact that when the second heated screen comes into contact with the first print, this has a tendency to re-melt and to smudge under the second screen. To obviate this, the Americans advise keeping the object at a certain distance from the screen, and also to work at a very high speed, say 3,600 per hour. This, however, is not always possible on the machines for small productions for which there is always a call. We have overcome this difficulty in using enamels which melt at varied temperatures, for instance, if our first colour were a white of which the melting point was 90°, we would use a second colour which would melt only at 60°, and in this case the second screen would not be warm enough to affect the first colour.

Thermo-plastic enamels can very well be used in conjunction with ordinary enamels, and if we had three colours to print, we could very well do the first two colours in thermo-plastic enamels, and the third colour in an ordinary enamel. On a two-colour job we could print the first colour in thermo-plastic and the second colour in an ordinary enamel.

Glass works call for much higher production than potteries, and for their purpose we had to build machines whereby the feeding and printing in three colours is done simultaneously. This has been done with turntable machines where the bottle is fed between a chuck and a point without any registration mark; it then goes under the first screen and collects the first colour, the bottle then drops, and the turntable places it under the second screen, where it is raised again and takes the second

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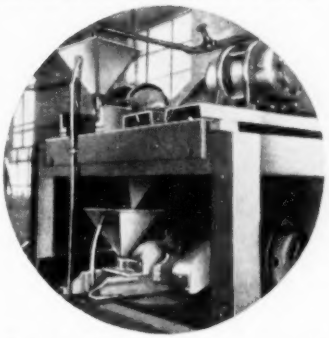

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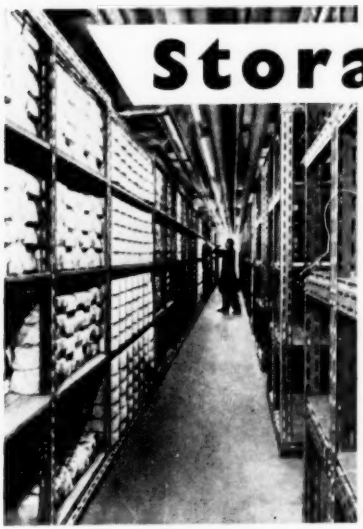

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colour in very accurate registration as the whole process is mechanically operated. The third colour is done in the same way, and it only remains for the operator to collect the bottle which has been printed in three colours at the speed of about 2,000 per hour.

The machine has also been designed to always print in the same direction. This is absolutely necessary, as when the screen is heated the mesh has a tendency to slacken, and we have seen that when this happens the stretch of the mesh would give variations in the registration if the squeegee operated both ways.

Misprints are therefore reduced to a strict minimum; this cancels out waste of enamel and of labour to clean off the misprints.

Rapid Development

We are told that in America these new enamels are already in use on the very large machines mentioned previously and the drying ovens have become obsolete, although these models are only 2 or 3 years old. This shows that the technique is developing so rapidly that even quite recent machines can be replaced by something very much better.

No doubt these plastic enamels with immediate drying will lead to further developments, and it is very probable that in the very near future we shall see thermo-plastic inks which will be adopted by the printing trade and there is even a possibility that paper will be printed by the screen process with immediate drying, which would enable very high speed.

Fusing Kilns and Lehrs

Two types of ovens are used:

(a) *Kilns.*—These are used when small productions are required, most of them are electrically heated and their cubic capacity varies considerably. These kilns must be well ventilated, as the air must contain plenty of oxygen. The usual way to obtain this result is to heat the oven to about 300° C. before closing the door, as this is the temperature at which the media is burnt out.

(b) *Lehrs.*—This type of oven is reserved for large-scale production. The length varies very much, say, between 10 and 40 metres. The width depends on the type of production required, but it is advisable not to go above 1·20 m. to 1·50 m. These lehrs are heated in every possible way, although electricity is rarely used on account of its high cost. Town gas is very often used. Fuel oil is also used frequently, but great care must be taken to have good ventilation as fuel oil contains a lot of sulphur which would cause trouble with the enamels, making them lose their shine and attacking the colours. The best results are obtained when the heating is done both below the belt and on the crown; these two heating systems being independent allow a very accurate control.

In the case of enamels very difficult to fuse it may be necessary to heat the base much more than the crown. In this case heating of the base should give a satisfactory fusion of the enamels without the mesh of the lehr belt marking the articles.

The lehr consists of the pre-heating zone, in which all the oils of the media evaporate before the articles reach the fusing chamber. In the case of silk screen decoration this pre-heating section of the lehr should be short, and the temperature raised quickly to obtain complete evaporation of the oils. For decoration by transfers the pre-heating does not need to be as fast. A correct ventilation of the lehr is essential for the same reasons as for the kiln type. It is absolutely necessary for white or pink enamels to be fired with plenty of oxygen, and in consequence the vapours of the media must be quickly chased out of the fusing chamber. A damp atmosphere is also bad for fusing. This is the reason why screen decorations will show bubbles if fused in a new lehr where the dampness has not been properly dried out. It is an advantage to fire the ware fairly quickly after decoration as the oil has a tendency to oxydise, and it then becomes more difficult to eliminate. The temperature of the lehr must be very accurately controlled by means of a registering pyrometer.

As the thermo-couples must be kept at a fair distance above the articles the pyrometers will not indicate their true temperature, but they will, however, serve to maintain the correct heat in the lehr. Very high precision can be obtained in this way, and this precision is

necessary as some enamels fuse at temperatures allowing only of a few degrees variation.

Articles in Thin Glass

What has been said above applies to glass with thick walls. In the case of ampoules or tubes with thin walls, the lehr does not need to be so long. These articles can be heated and cooled much quicker without causing strain. The lehrs can be very short, say, 1 m. to 1·50 m., the only difficulty being that the printed part of the tubes must never touch another article, as the thick coat of enamel would smudge.

To overcome this the printed articles are carried in cradles and held only by the two extreme ends. The conveyor belt, made up of these cradles, goes through the electric furnace and the enamel is fired very quickly. The media used for this enamel must enable very quick firing without making bubbles, so that the enamel remains glossy. In these lehrs, the temperature indicated by the control apparatus will be considerably higher than the temperature necessary to fuse the enamels. As the articles go through the lehr very quickly, they have to reach fusing point in a very short time, and for this reason the temperature of the walls of the furnace itself must be considerably higher than fusing point. This of course would not apply when working on thick-walled glass, where the temperature of the lehr is always very close to the actual fusing point.

THE BRITISH CERAMIC SOCIETY

THE following are the titles of papers appearing in the November issue of the Transactions of The British Ceramic Society:

"Some Aspects of the Corrosion of Refractories," by N. McCallum and L. R. Barrett.

"Past, Present, and Future Trends," by A. Williams-Gardner.

"Jet-Drying of Whiteware," by G. W. Bird and A. J. Dale.

"The High-Frequency Drying of Clayware: Theory and Practice," by S. Copeland.

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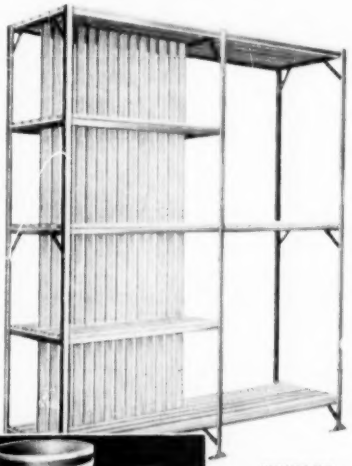

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GLASS WORKERS' CATARACT

THE hand-blowing and fabricating of glass is one of the oldest man-made occupations known.

And glass-blowers' cataract is one of the oldest-known occupational diseases. At least that is what we believed until recently. Now the surprising doubt has been mentioned whether cataract is a real occupational disease of glass-blowers, or whether no such occupational ailment exists.

What is a Cataract?

It has been known for a long time that certain occupational influences, such as an electric current, may produce a cataract of the human eye.

A cataract is a peculiar disease of the eye which consists in the loss of transparency of its lens. All light we see has to pass through the lens of the eyes. When, for some reason, the lens becomes opaque, a gradual loss of vision will result, followed gradually by blindness. The pupil of the eye, which usually is black and transparent, has a coloured shine and becomes opaque in such cases.

A cataract sometimes occurs as the result of injury, and then may be found in young people. Sometimes it is due to a general disease such as diabetes. The most common form, the cataract of old age, appears after the age of fifty; it is caused by a degeneration or loss in vital power in the tissue of the lens, the real cause being unknown.

About occupational cataract, the medical textbooks say that it occurs often in glass-blowers, iron founders and other workers exposed to great heat or intense light.

The development of a cataract is slow. The average period of ripening (that is until the entire lens is opaque) is about two years. The first sign of a beginning cataract may consist in persistent tiny specks before the eye. Vision then becomes gradually worse. It depends on the situation of the cataract which is worst when the cataract is centrally located, lesser when the cataract is forming at the periphery of the lens. In looking at the eye, the pupil will appear greyish.

Glass-blowers' Cataract

Glass-blowers' cataract has been described in many countries. Dr. J. Badot has reported that among a series of 200 cases of cataract occurring among glass-blowers, 5 per cent. occurred below the age of forty years; 42 per cent from the ages of forty to sixty years; and 53 per cent in the age group from sixty to eighty years. Glass-blowers' cataract has been variously ascribed to the action of the intense heat and light, to the excessive sweating of the workers, and to the ultra-violet and infra-red radiations to which glass-blowers are exposed.

A study has recently been published by Karl L. Dunn, industrial hygienist, Corning Glass Works. When, some years ago, he was assigned to conduct a programme of industrial hygiene for one of the largest of the glass manufacturing concerns, he was struck by the fact that the hand glass-workers were being exposed to infra-red radiation. The medical director and the company ophthalmologist indicated that neither of them had ever seen or heard of a cataract in a glass-worker. The company has a record of about 100 years of glass production, and in the last thirty-one years, for which period medical and insurance records have been preserved, no case of glass-workers' cataract has been recorded and no claims of failing vision or eye disorder in glass-workers have been filed.

The various workmen's compensation laws have their origin in England. In 1903 an article on "Bottle Finishers' Cataract," was published by William Robinson, M.D., in the *British Medical Journal*. In it the great light and heat of the furnace at which the bottle finisher works, were held responsible for cataract formation, and Robinson's

study was the basis for the compensation regulations later by British law.

In direct opposition to Robinson's data are investigations conducted by Simeon Snell, professor of ophthalmology at the university in Sheffield, England. His experiences in a large bottle-making district lead him to the conclusion that men engaged in the bottle trade "are not liable to cataract to such an extent as has been asserted."

Mr. Dunn, in his study, examines the different stages of glass-making; the gatherer, whose duty it is to gather a mass of glass on the blow-iron or punty for shaping; the ball-maker, who forms the "gather" into such a shape as to allow it to be introduced again into the molten glass; the finisher who is "warming in" a glass object in a reheating kiln; the gaffer or glass-blower who forms the hot glass blank into its final shape by blowing it into a hollow mould; the mould holder who opens and closes the hollow mould into which the gaffer blows the hot blank; the pressman who shears off the desired quantity of molten glass.

Error in Original Investigation

None of these workers had ever heard of glass-blowers' cataract. Mr. Dunn found, in the whole presence and history of the company, no case of cataract, although workers have been exposed to extremely intense infra-red radiation for many years. He believes that there were errors in the original investigation of a high incidence of cataract in a group of British glass-workers. Possibly the real cause of the high incidence of cataracts in those early studies was not discovered.

Mr. Dunn suggests that new research should be conducted in groups of persons suffering from cataracts of all forms from the standpoint of general physiology, race, diet, occupations, etc. It might also be helpful in other trades and exposures to review the earlier works on occupational diseases, with a view to adjusting some of the present-day opinions.

Experimental Cataracts

Glass-blowers' cataract has been surveyed by M. A. Shah in India. In the beginning it is like a cobweb in structure, and saucer-shaped with a definite "brass" colour when inspected closely. He carried out experiments whereby heat was imparted to the eye while no infra-red rays were used.

From the results of these experiments, Dr. Shah concluded that permanent cataractous changes in the lens can be produced by moderate heat when it is unassociated with infra-red rays. The cataract so produced does not conform to the type of glass-blowers' cataract.

Cataracts have also been produced experimentally in animals by the passage of an electric current through the eye. No other abnormality, but cataract developed in the eye.

It is interesting in this connection that radio waves and diathermy waves in normally-used intensities have never been shown to produce a cataract. However, cataracts might be caused by X-rays.

If actually a cataract develops, whatever the cause may be, the best-known treatment is operative removal of the opaque lens at a time when the cataract has ripened. If cataracts have developed on both eyes, only one is removed at a time.

After the removal (extraction) of the lens, it will be necessary to provide the patient with an artificial lens in order to restore his vision, which means, with glasses having convex lenses similar to the natural lens. Operative treatment of cataracts is a highly-successful progress in modern medicine.

REFRACTORIES

WE have received from the Leeds Fireclay Co. Ltd., Wortley, Leeds 12, a booklet entitled "Refractories." The publication should be of great interest and assistance to all users of refractory materials, for not only are full particulars of the various kinds of refractory materials given, but a clearly illustrated section is devoted to special shapes. Another section of the booklet is devoted to illustrations of plant, typical of the many and various contracts where "Best Wortley" refractories are used. Useful tables for various essential calculations, and full illustration and details of most of the standard shapes, are also included.

RECENT PROGRESS IN CERAMICS

AN interesting paper which was originally presented to the London Section of the Society of Chemical Industry, appears in *Chemistry and Industry*, 22nd November, 1952, entitled "Recent Progress in Ceramics," the author of which is Mr. A. Dinsdale, M.Sc., F.Inst.F., superintendent, British Ceramic Research Association.

In his introduction, he says the word ceramics is a general term which can conveniently be used to refer to a group of industries making such diverse products as pottery, refractories, building materials, electrical porcelains, and so on. There are many important subdivisions of these industries, and it would be impossible to deal with them all in a single review. Even to attempt to review progress in all the major sections would be an unprofitable enterprise, since nothing more than an uninformative skimming of the surface would be achieved. It has, therefore, been considered advisable deliberately to limit the objective, and to give a rather more detailed account of two selected topics. It seemed fitting to choose one topic of a scientific nature and the other dealing with an industrial process, since the Society and the Research Association are alike concerned with both science and industry.

In making the choice, certain unifying considerations have been allowed to weigh. Apart from certain special products, all the industries included in the field of ceramics are based on the use of clay as the fundamental raw material, and on firing as the essential manufacturing process. What has been attempted, therefore, is to describe (a) the modern outlook on the structure of clay, showing particularly how X-ray, thermal analysis and electron-microscope techniques are all being used to build up the complete picture; and (b) the development during the past few decades, especially in the pottery industry, of new and improved methods of firing.

Continuous Firing

Mr. Dinsdale concludes by listing the more important improvements which have resulted from the introduction of continuous firing, as follows:

(a) A more uniform heat treatment of the product. The heating of any large bulk of material necessarily involves non-uniformity of temperature, and the tunnel oven, by virtue of the reduced size of the setting, produces ware of a more uniform quality than does the intermittent oven. In some cases this may be very important; for example, a close control of fired size is highly desirable in the manufacture of tiles. In addition to the improved uniformity over the setting as a whole, the tunnel oven allows more accurate control of temperature and hence shows less variation with respect to time.

(b) A more uniform flow of ware and a more rapid turnover. The tunnel oven, with ware being continually placed at one end and drawn at the other, can be made to fit admirably into modern conceptions of flow production. The firing time required is frequently less than half that required in the intermittent oven, which means a substantial reduction in the total time required for the making of a particular article.

(c) A higher thermal efficiency. In the coal-fired intermittent oven the thermal efficiency, defined as the proportion of the heat input used in heating the ware, is frequently below 5 per cent. This figure may be increased several-fold in gas-fired tunnel ovens, and may be more than ten times as high in electrically-heated ovens. It is, of course, true that this increase in efficiency is to some extent offset by the loss of efficiency in the preparation of processed fuels, but even when this is taken into account and the fuel consumptions are related to the original coal, it is still found that the tunnel oven only uses about half as much fuel as the intermittent for biscuit firing, and still less for glost. It is generally found that, in spite of the higher cost of derived fuels, the tunnel oven shows an appreciable saving in fuel costs.

(d) A diminished use of solid fuel. From the national point of view, and from considerations of smoke abatement, the increasing use of the tunnel oven in the pottery industry represents a marked advance. During the period 1938-1951 it is estimated that the consumption of coal was reduced by half, the amounts of gas and electricity having increased respectively to three and four times their former value.

(e) A reduction in labour and maintenance costs. The demands of the

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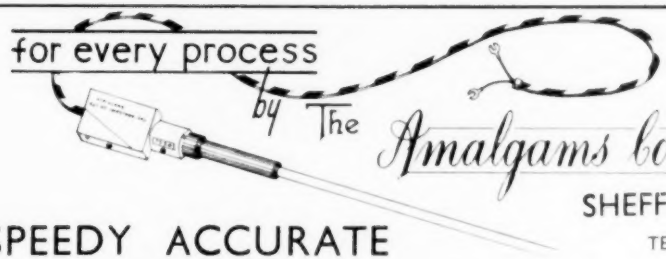

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intermittent oven on labour for setting and drawing the ware, and for work associated with the firing were very heavy and have been substantially reduced by the use of continuous firing. The available data consistently show that the reduction in cost which ensues is of the order of 50 per cent. and that this represents the most certain and important advantage to be gained. It is also found that the wear and tear on tunnel ovens is negligible, but is very heavy on intermittent as a result of the high thermal stresses set up by frequent heating and cooling of the structure. This is, of course, to some extent offset by the high capital cost of tunnel ovens.

Outline of Developments

The advantages indicated above are sufficient to ensure that the use of tunnel ovens will continue to increase, and that intermittent firing will eventually disappear. It might be fitting in conclusion to outline the developments which have led up to the present position, in order to show the transition in its true historical perspective. It is not known with certainty when tunnel firing was first discovered, but it is generally agreed that it was early in the eighteenth century. Certainly a continuous muffle kiln was built at Vincennes in 1751, but the ware was pushed through. The idea of using cars with wheels was probably developed in the middle of the nineteenth century for the firing of bricks. A number of tunnel ovens for pottery were built on the Continent in the early years of the twentieth century. In this country, although one or two ovens had been built previous to the first world war, the year 1920 seems to mark the beginning of considerable interest and activity. From then until 1939 the number of tunnels in use grew steadily; the first one to be fired on town gas was built in the Potteries in 1932 and sixty-six such ovens were operating by 1939. Although there is a record of experiments with electric heating in the early years of the century, the development of electric tunnel ovens is a recent one, culminating in the building of a twin-track, high-temperature kiln in 1939. The rapidly increasing tempo of development was seriously impeded during the war years, but greater advances have been made since 1945 than ever before. Since 1938 the number of tunnel ovens in use in the pottery industry has increased from about ninety to about 260. Most of the decorating firing, the majority of the glost firing, and a substantial proportion of the biscuit firing is now carried out in this way.

Many problems remain to be solved, and improvements in design and operating technique are continually being introduced. If this survey has conveyed the sense of a major industrial development, it remains to conclude that this can lead only to still more change in future.

The author acknowledges his thanks to the Director, Dr. A. T. Green, O.B.E., and to the Council of the British Ceramic Research Association for permission to present and publish this paper.

BOOK REVIEW

"The Science of Flames and Furnaces"—M. W. Thring, M.A., F.Inst.P., F.Inst.F., Head of the Physics Department, British Iron and Steel Research Association. (Chapman and Hall Ltd. 42s.)

AS is pointed out by the author, furnace research as such has tended to be overlooked, largely because furnaces were known and in existence some time before the question of the application of physics or chemistry to their design had produced any worth while contributions. The author has set out to gather together existing knowledge on fluid flow, combustion and heat transfer in a manner which is most useful for both furnace designers and engineers. It should be very useful to those designers and users of furnaces in the metal, glass and ceramics industries. The cost of heat today—whether coal, gas, oil or electricity is employed—is becoming increasingly high.

The author deals in detail with the function of furnaces, the thermodynamic principles covering furnace heating, the liberation of heat by combustion, heat transfer, the aerodynamics of hot systems and the science of furnace construction, with particular emphasis upon refractories. In his concluding chapter entitled "The Application of the Scientific Method of Furnaces" he first of all points out the limitation and then goes on to say how it may be applied and translated into practice.

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CUP "HANDLING" MECHANISED

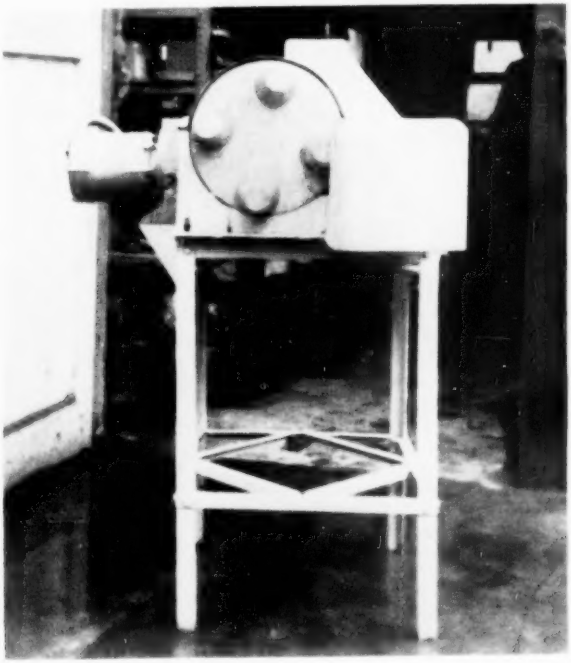
by

T. WATHEY

A DEVELOPMENT of interest to the manufacturer of earthenware cups, and other similar "handled" vessels, lies in the recently patented "Fryer" cup handling machines (prov. pat. 33293).

The purpose of the machine is to provide better "handling" facilities than are possible by the use of hand methods. In short, the machine has been designed to give uniformity of positioning and positive adherence of handles, coupled with a possible high rate of output—to provide means, in fact, of good "handling" in mechanised form.

Even with the best of hand "handlers," positioning is liable to become a little irregular towards the end of a working period. While output, which at the beginning of a shift may average 2½ "handlings" per min., tends to fall off, more or less, about mid-afternoon. Another drawback of hand "handling," which becomes apparent on close examination of the hand process, is the practice of hand cutting handle "heads and tails" prior to their attachment. Such cuts, instead of being hollowed to fit the cup, are often square, with the result that the square-cut ends must then be forced to the rounded shape of the cup—an obvious cause



The "Fryer" cup handling machine

of "sprung" handles, and of air cracks between handle and vessel.

The Machine

The "Fryer" machine is a self-contained appliance occupying a floor space of 3 ft. by 2 ft. It incorporates devices which make it easy of operation by the unskilled, who, it is claimed, should "handle" twelve cups per min. with ease.

The machine is powered by a ¼ h.p. motor, which drives a two-speed driving shaft through a reduction gearbox. In turn, this shaft drives both a chain conveyor, which carries the handles in holders, and a rotating face plate equipped with four specially-designed cup chocks. The chain conveyor is fitted with a series of slides to which are attached the handle holders. These holders, which are interchangeable on the slides, may also be varied in their internal shape in order to enable application of all the usual types of handle. It may also be mentioned that in fixing open handles, no special attachments are necessary.

Operation is simple. A handle is placed in a holder at what may be termed position one. Holder and handle are then conveyed to position two, where a guillotine actuated by means of a camshaft and rocker arm comes into operation. The guillotine, which is capable of fine adjustment, enables the simultaneous, automatic cutting of handle "heads" and "tails" to fit both the radius *and* the contour of the vessel to be handled.

Shaping completed, the handle moves to position three. Here, slip is applied to "head" and "tail" by means of a belt, which is moved intermittently through a trough of slip, the contents of which are subjected to constant agitation in order to prevent settlement. In this way, a predetermined quality of slip of the desired consistency is always available for application to the handle, an operation which is performed through the agency of a cam-operated applicator arm, which at the required moment brings the handle ends and slip belt into contact.

Attachment

At position four the holder with its handle is brought into juxtaposition with the chock-equipped face plate, and its loading of handleless cups. It is at this point in the cycle that "handling" takes place, and this operation, in which the handle is gently affixed to the cup, is, as in the case of the guillotining and slipping already described, also actuated by cam and rocker arm.

At this point it will be of interest to describe the special cup chocks. Their design is unique, for not only do they allow of adjustments to cope with size variations due to worn making tools, but they also give—by means of internal springing—a balanced pressure on both "head" and "tail" of the handle at the precise moment of attachment. Such are advantages not given by the more usual solid chock. In practice, too, a sprung chock gives a cushioning effect during "handling" which prevents both cup distortion and cracking inside the vessel immediately behind the point of attachment of the handle.

The machine also provides for a positive pressure release immediately following attachment of handles. This effectually releases pressure on both cup and handle, and prevents distortion of the latter in its finished state.

Operation

From the working standpoint, operation of the machine is simplicity itself. It is provided with a sheet metal cover in which is fabricated a troughed opening, and it is through this that handles are fed into the holders. Following this, as already described, the handles pass to guillotine and slipping belt, and these operations may be checked through the Perspex window provided in the cover in order to give means of observing progress.

Cups are slid on to the spring-loaded chocks already mentioned, and the face plate to which they are attached is moved in anti-clockwise direction to the "handling" point. Following "handling," the vessels ride to the unloading point whence, after light sponging, they are passed to the "greenhouse" *en route* to the kiln.

Mention has been made of an output rate of twelve cups per min., and it will be obvious that in this regard much will depend on facilities for

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speedy movement of articles to and from the machine. In addition, as the makers of the machine point out, high outputs from devices of this nature depend to a great extent on the co-operation given by the operative; and given this it is claimed that rates of "handling" exceeding twelve per min. are within easy reach.

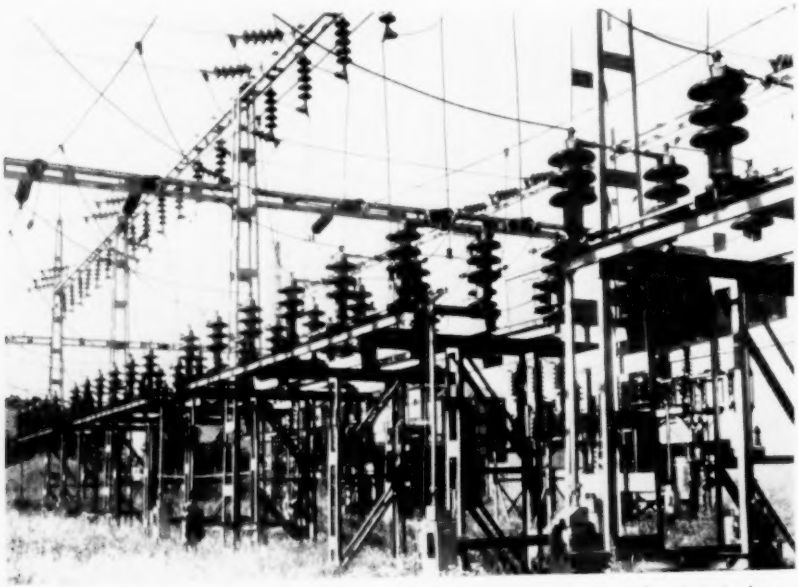
Acknowledgments and thanks for assistance given in the preparation of these notes are due to Mr. A. Fryer, Fryers (Engineering) Ltd., Victoria Road, Fenton, Stoke-on-Trent.

THE NEW HARSPRANGET POWER PLANT

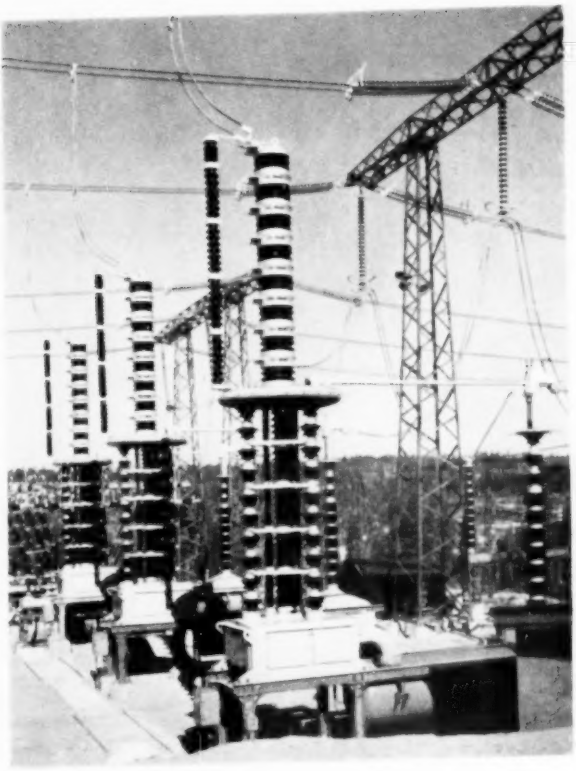
By

JOHN GRINDROD, B.A.(Com.)

AMONG the firms prominent in supplying equipment for the new Harspranget power plant in Sweden has been AB Ifoverken of Bromölla, one of Europe's leading producers of pressed components and electrical insulators. As principal suppliers of electrical porcelain to the well-known Swedish electrical engineering firm of Allmanna Svenska Elektriska Aktiebolaget A.S.E.A. of Västeras, who were the main contractors for the apparatus installed on the Harspranget project, AB Ifoverken have made most of the high tension porcelain used in the equipment. This included pedestal insulators and insulator porcelain for transformers, condensers, contact-



Some of the types of insulators used in connection with the new Swedish hydro-electric supply from Harspranget



One of the 380 kV. air blast circuit breakers on the transmission line manufactured by A.S.E.A. with Iföverken insulators

breakers, etc., for the power plants and switching stations. Also they have supplied suspension insulators for the transmission line up to the limit of their capacity at the time.

Officially opened in June last by King Gustav Adolf, the new large Harspranget hydro-electric scheme represents a milestone in Swedish water power development and in world power transmission technique. Taking seven years to complete, and costing £19 million, the new plant has two notable features—the 350,000 kW. station itself and the 600-mile trunk line, by means of which power is transmitted from the Arctic to Central Sweden at a potential of no less than 380 kV., the highest potential used in the world for power transmission.

According to the Swedish Standard Specifications a 380 kV. transmission system calls for a station insulation corresponding to insulation class 1,775, that is to say an impulse withstand voltage of 1,775 kV. on 1/50 full waves. Although the standards apply to a system not directly earthed, and, in a system directly earthed, it should be permissible to reduce the insulation level somewhat, certain complications in the Harspranget line made the saving in cost of such reduction so slight that it was decided to insulate at the higher level. Thus, both transformers and circuit-breakers as well as the other switchgear equipment are designed for insulation class 1,775. At this level the voltages applied in withstand tests would be 1,775 kV. for impulse test on 1/50 full wave, 976 kV. for 50 c/s A.C. dry test, and 781 kV. for 50 c/s A.C. wet test.

Various types of insulator elements have been used on the transmission line suspension strings, details of which are given hereunder:

Type of Insulator	Spacing (in.)	Number used	Flashover clearance across string (in.)	Impulse strength at positive impulse $\frac{1}{2}$ when wet kV
Porcelain—Swedish	6·70	20	115	1·580
High-tensile glass—British	6·25	22	119	1·620
Porcelain—American	5·75	23	113	1·560

The factors determining line insulation have been provision against flashovers due to lightning or switching surges and against excessive voltage stresses across the lowest line insulator elements. The latter factor has been reduced to a safe value by the provision of a grading ring. The two porcelain type insulators are used for a normal working load of up to 4 tons. At higher loads of up to 5·5 tons the high-tensile glass type has been used. The Swedish porcelain type, one of the most commonly employed, has a 50 c/s withstand-voltage of 940 kV when dry and 760 kV when wet.

About one-third of the suspension insulators for the transmission line, as well as most of the high-tension porcelain have been made at the modern Swedish factories of AB Hoverken at Bromölla who have been producing ceramic materials for half a century. Having been making insulators and other porcelain ware for the electrical industry since 1918, they are now one of the most up-to-date firms in this field in Sweden, if not in Europe. Electrical equipment made by them includes suspension and line insulators, installation fittings, fuse cartridges, junction boxes, fuse bottom rings, etc. Moulded products are manufactured in porcelain, steatite, cordierite and chamotte, according to the electro-technical purpose for which they are required. Other products outside the electro-technical range embrace vitrified sanitary ware, coloured and mosaic floor and wall tiles and refractory bricks and mortars. Though most of the electrical porcelains are based on the use of feldspar, clays and flint, some of the newer ceramic products consist of pure oxides of such metals as aluminium, zirconium and magnesium. Clays are found in rich deposits in the region of Bromölla which lies on the banks of Lake Ivo in Skane.

Gas-fired tunnel kilns were introduced into the works in 1933 and the company now has thirteen of these in operation at the plant. Six intermittent beehive kilns are used for making very large bushings and insulators. The latter are fired with tar derived as a by-product of the gas generators. In addition there are a number of kilns equipped with oil burners.

After processing the feldspar clays and flint into filter cakes, the latter are dried at 155–157° F., keeping the body "alive." They are then broken down into powder, meshed and mixed with oil and water. Manual and automatic presses mould the mixture into the required shapes, which, after drying, are glazed. Dry powder is also moulded under pressure.

An entire floor at Hoverken is given over to the manufacture of precision dies which are used particularly for making components which have to be assembled with metal parts. Another method adopted, which removes air bubbles and increases dielectric strength, is extrusion under vacuum. Steatite has many advantages for this purpose.

For large insulators the clay mixture is put through a pug mill, the blanks being turned to required shape on a lathe when they have been dried to the right consistency.

Long selenium cell-controlled conveyor belts take the pressed components to the dryers and to the hydraulic loading platform where the carborundum saggars are loaded on to trucks for the kiln. After having been fired at 2,570° F. and subsequently cooled the electrical porcelains are tested for strength and their reaction to high frequency current. Results normally show a

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dielectric constant of six, a flexural strength of 9,940-10,650 lb. per sq. in., and a compressive strength of 99,400 -113,600 lb. per sq. in. The checking of high-power line insulators in the laboratory and the firm's pilot plants consists of submitting them to 70-120 kV., 50 cycles for 20 min. This is interspersed with a 10-sec. high-frequency breakdown jolt. Large bushings are tested at 500,000 v.

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Prior to their work for Harspranget AB Ifövérken had supplied power lines in Sweden with some 2,500,000 suspension unit insulators.

The Combustion Engineering Association.—The Association, at 6 Duke Street, St. James's London, S.W.1, announce the publication of a book, "Firing Equipments and their Fuels—Part 1, Shell Boilers Fired by Solid Fuel." The price of the book, available from the offices of the Association or from the Hon. Secretary, Northern Section, 9 Quebec Street, Leeds 1, is 10s. post free.

METHODS OF TESTING REFRACTORY MATERIALS

THIS standard (B.S. 1902:1952), which has just been issued by the British Standards Institution, describes methods of test having a general field of application and is based on the work of the Testing Committee of the British Ceramic Research Association. It relates more particularly to fireclay and silica refractories.

Standard Tests

The following standard tests are described: chemical analysis, including the determination of hygroscopic water, loss on ignition, determination of silica, ferric oxide, titania, lime and magnesia and determination of alkalis; physical tests, including the determination of porosity and density, true specific gravity, permeability to air, refractoriness, refractoriness-under-load, permanent linear change on reheating, cold crushing strength, reversible thermal expansion and resistance to the disintegrating effect of carbon monoxide. A tentative test for resistance to thermal shock is given.

Copies may be obtained from the British Standards Institution, Sales Branch, 24 Victoria Street, London, S.W.1. Price 7s. 6d.

SUPER REFRACTORIES

By

R. H. WARRING

THE engineer will identify silicon carbide as the material from which grinding wheels are made. The ceramics technician will identify it as a modern refractory material. The chemist or scientist will probably think of it as one of the hardest of man-made materials, prepared in the electric furnace at high temperatures from a mixture of silica, sand and coke.

It is perhaps significant that, in recent years, the role played by refractories in industry is expanding. With the introduction of new refractories, all products of the electric furnace (mostly bonded silicon carbide and bonded fused aluminium oxide), many of these refractories have replaced metals in engineering and industrial applications. This has opened the door to higher processing temperatures, often resulting in increased capacity or increased efficiency, or even made possible processes hitherto impossible or impractical.

Two typical, and contrasting, operations can be quoted. Rocket motor throats produced of silicon carbide have proved far more durable than the best of high temperature steels for rocket motors. Silicon carbide retains its strength and rigidity at temperatures approaching 3,000° F., whilst almost all heat-resisting steels begin to weaken above about 1,500° F. At the other end of the scale much of the metal zinc is now produced by a process which has only been made possible by the introduction of super refractory materials. The vertical retorts used in ore reduction just would not stand up to the job if made from one of the older refractory materials.

Applications

Broadly speaking, the applications of super refractories can be divided into three classes: the replacement of normal refractories with super refractories, permitting higher working temperatures and giving longer life, corrosion resistance, etc., i.e., use as refractory materials; as heat-resistant secondary structural members, largely

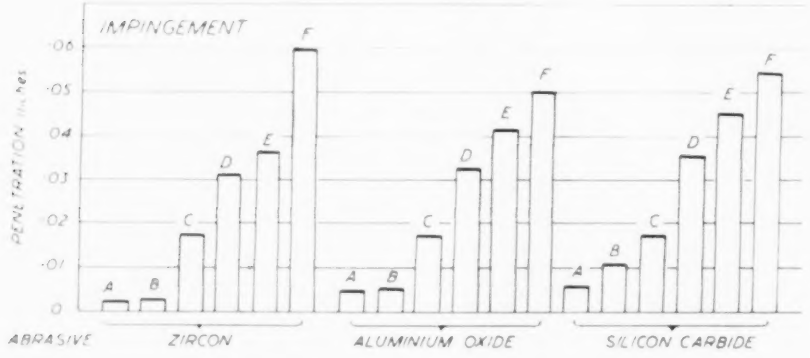

Fig. 1

A. Fused cast alumina; B. Bonded silicon carbide; C. Basalt cast brick; D. Firebrick; E. Paving brick; F. Plate glass

replacing metals; and as corrosion- or wear-resistant materials, again frequently replacing metals.

The properties of bonded silicon carbide or bonded fused alumina are unique, and controllable during manufacture. For example, the basic materials are very hard refractory substances. The type of bond employed during manufacture can be varied, as necessary, to improve hot strength, abrasion resistance, chemical stability or any other characteristic of particular importance for a specific application. Additionally, grain combination can also be modified, permitting an almost unlimited number of super refractories to be produced, each with certain desirable properties enhanced.

To get a better idea of what these properties are, a comparison can be drawn with normal refractory materials, like firebrick. Typical data was summarised in Table I. As far as heat resistance is concerned, super refractories have P.C.E. values of between 37 and 40, on average, as compared with 31 to 33 for high duty firebrick and 33 to 34 for the best of super duty firebrick. This means that super duty refractories can be used quite safely at temperatures in excess of 3,000° F.

Even more important, however, is comparable hot strength values. Bonded silicon carbide refractories can withstand a crushing load in excess of 300 p.s.i. at 2,750° F., without failure whilst the best of firebricks at comparable temperatures seldom exceeds a hot strength of 25 p.s.i. Bonded silicon carbide also has a higher resistance to thermal shock.

Another and rather unusual property where refractory materials are concerned, is that some super refractories are good heat conductors. Normally one thinks of a refractory as retaining or containing heat—heat insulators, in other words. Super refractories of the bonded fused alumina type fall into this category, like fireclay. Many bonded silicon carbide refractories, however, have thermal conductivity characteristics similar to those of high temperature alloys. They are particularly useful, therefore, in dissipating heat from furnace structures, especially in processes involving high heat releases.

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TABLE 1. REFRACTORY MATERIALS COMPARED

Refractory	P.C.E. Rating	Density lb./cu.in	Coeff. Expn. per of (60° F–2,400° F)	Specific Heat B.Th.U./lb. F	Modulus of rupture at 2,550° F P.S.I.	Abrasive Resistance	Spalling Resistance
Bonded silicon carbide	37	092	2·6 × 10⁻⁶	028	800-3,125	Excellent	Excellent
Bonded fused alumina	37-40		1·0 × 10⁻⁶		50-1,050	Excellent	Very good
Bonded mullite	38-39		4·5 × 10⁻⁶		100- 575	Good	Excellent
Fireclay	30-32	07-09	3·0 × 10⁻⁶	027	0- 290	Good	Low
High duty firebrick	31-33	07-09	3·0 × 10⁻⁶	027	0- 400	Very good	Low
Super duty firebrick	33-39	07-09			0- 400	Very good	Fair

Nearly all the super refractories are extremely resistant to abrasion from room temperature up to temperatures in excess of 3,000° F. They are particularly useful, therefore, as liners for flues and ducts carrying abrasive particles, coke chutes, dust collectors in ore sintering machines, and so on. In typical applications they usually outlast steel plates by some four to five times. Chemical inertness is another factor promoting long life under even the most arduous conditions. They resist attack by most acids and silicon carbide refractories are now used to line gas ducts and liquid containing vessels in sulphuric acid plants and in many other processes associated with chemical engineering. In a good many cases these refractory materials are used at low temperatures, i.e., not for their refractory properties but for chemical- and wear-resistant properties only. During the manufacture of steel wire as it is drawn it is passed through a chemical bath to receive a zinc coating. Guides made of silicon carbide refractories have superior resistance to the combined cutting action of the wire and corrosive action of the plating solution than any other known substance.

Impingement and Abrasion

Fairly recently a series of tests were conducted by the Carborundum Co. of America to determine the abrasion resistance of typical refractory materials, with particular emphasis on their possible application to blast furnace operation for linings, chutes and so on. Both impingement tests and direct abrasion tests were made, using silicon carbide, aluminium oxide and zircon grain as the abrasive materials. All abrasive grains were 100 mesh size.

In the impingement test a machine directs a blast of air against the surface of the material to be tested while a definite volume of abrasive is fed into the airstream. The penetration or depth of erosion is then determined.

In the direct abrasion test a motor-driven notched wheel is rotated in contact with the test surface. Loose abrasive grain is fed into the wheel notches to produce the required abrasive action. Again similar abrasive particles were used, screened through 60 mesh. The 6-in. dia. wheel was rotated at a speed of 44 r.p.m. and

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each test run was limited to 25 revolutions exactly. The depth of material removed was then measured.

Results of these tests are summarised in the graphs, Figs. 1 and 2. The plate glass specimen was largely tested as a control, although it is not without practical significance. Many ceramic bonds are of a glassy type and it is obvious that the overall resistance of such a bonded material is limited to the strength of the bond. Wear, as will be noticed, is relatively high.

The superiority of the super refractory materials is again demonstrated. The fused, cast refractories, show up

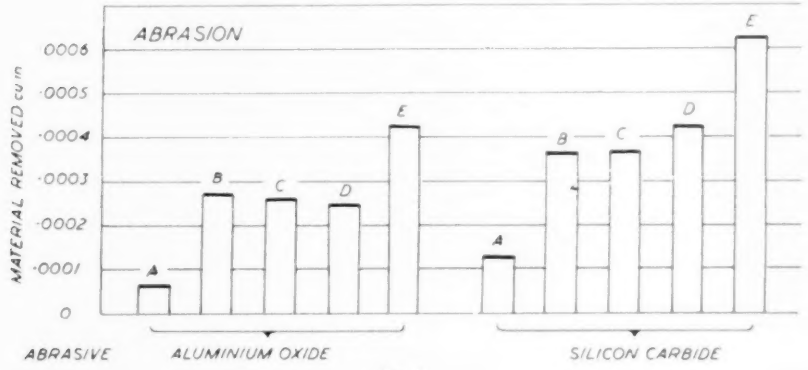

Fig. 2

TABLE 2. REFRACTORIES AND METALS COMPARED.

Properties	*Heat Resisting Steel*			*Refractories*		
	*A**	*B**	*C**	*Bonded Silicon Carbide*	*Fused Cast Alumina*	*Fireclay Brick*
Melting point °F.	2,550-2,590	2,550-2,650	2,550-2,750	3,308-	3,308-	3,056-
P.C.E. temperature, °F.	—	—	—	3,425	3,425	3,200
Density, lb./cm. in.	.29	.30	.27	.092	.09	.107-.09
Thermal conductivity (B.Th.U. hr./sq. ft./ft./°F.)						
212 °F.	9.5	8.0	12.0	—	—	—
1,000 °F.	12.4	10.8	14.1	8.7	.6	0.7
2,500 °F.	—	—	—	9.4	.9	1.0
Max. service temp. °F.				2,500	—	—
Continuous	1,600	1,900	2,000			
Intermittent	1,700	2,100	2,190	3,500	3,500	3,000
Emissivity	.38	.38	.38	.9	—	.75

* *Typical alloys.*

better in this respect than bonded silicon carbide. This is fairly easily explained by reference to the structure of these materials. The silicon carbide brick has a bonded grain structure, whilst the fusion cast refractories have a homogeneous structure throughout. As a matter of interest bonded silicon carbide is formed at a temperature of around 4,700 °F., whilst the aluminium oxide refractories are fused at about 3,700 °F. The grain crystals approach the hardness of diamonds in both cases.

These, and many other tests of a similar nature, together with practical experience in the use of super refractory materials under working conditions, confirm that for maximum wear resistance, as in blast furnace applications as a typical example, these new materials are a first choice, the higher the working temperatures involved the more severe the abrasion, or both, the more the advantages of the super refractories show up.

Comparative Costs.

As far as comparative costs were concerned, super refractories, on average, are between two and twenty times as expensive as conventional refractory bricks, but, generally, at least comparable in price with alloy steels. Bonded silicon carbide is cheaper than fused alumina. Against initial cost, however, must be reckoned the considerably longer life of the super refractories.

Typical properties of heat-resisting steel alloys and super refractories are summarised in Table II.

Undoubtedly all branches of industry will make even wider use of these super refractories in the future. The usefulness of these materials are not limited to their refractory properties alone. "Set a thief to catch a thief" might well be re-written "set an abrasive to resist an abrasive" for, after all, silicon carbide is still best known to most people as "the stuff they make grinding wheels from."

A New Hand Cleanser.—Boraxo (Braxo), a powder hand cleanser developed by Borax Consolidated Ltd., introduces new principles in hand cleaning. The product contains no insoluble or abrasive fillers and the scouring action necessary to remove ingrained dirt, or to penetrate oily films, is provided by the small grains of borax, which slowly dissolve during the wash. Boraxo in water solution is mildly alkaline—much less so than soaps in general. It has a *p*H value of 9.3, which is claimed to be sufficiently low to ensure no chemical damage to the skin and to prevent undue removal of natural fats. A working sample and full information will be sent, on request, by the makers: Borax Consolidated Ltd., Regis House, King William Street, London, E.C.4.

Distribution of Laboratory Glassware. It is announced that Baird and Tatlock (London) Ltd., scientific equipment manufacturers and laboratory furnishers of Chadwell Heath, Essex, W. B. Nicolson (Scientific Instruments) Ltd., of Glasgow, and W. and J. George and Becker Ltd., laboratory furnishers and manufacturers of scientific apparatus of London and Birmingham, have been appointed additional distributors for laboratory glassware by Quickfit and Quartz Ltd., of Stone (Staffs), a member of the Tripley group of companies.

BRITISH POTTERY MANAGERS' AND OFFICIALS' ASSOCIATION

ANNUAL DINNER

THIS function was held at the North Stafford Hotel, Stoke-on-Trent, on Saturday 13th December. The toast to the British Pottery Manufacturers' Federation was proposed by **Mr. I. R. Forse** chairman of the Hanley Branch of the Association. He said that his pleasure was a double one because they had present the President of the British Pottery Manufacturers' Federation in his official capacity and also because Mr. J. V. Goddard was a potter of repute, and was thus very welcome in his own right. He pointed out that pottery managers followed the affairs of the Federation with extreme interest and realised its value to the industry as a whole and to individual member-firms.

He continued to say that the Managers' Association also believed in its own value and he felt sometimes that its collective value was not always appreciated. He said that they did not wish always to fill the rôle of Cinderella. He continued:

"As managers, our skill and knowledge have been acquired the hard way. We start out on our careers believing that in the overall pocket of every counter-out there lies a director's cigar, and even though time may modify our views, we still aim, as individuals, to reach the highest possible spheres of management.

"We are not a neutral half-way house between the Pottery Workers' Union and the Manufacturers' Federation. It is true that our members understand in a down-to-earth way the outlook and the problems of the operatives, and understand them as few directors, however well-meaning, can do. It is also true that we understand the problems and outlook of the Board of Directors as few operatives are able to do. We have even been known to tackle and solve problems to which neither operatives nor directors have found the answer—but we are not neutral.

"Our aims and our ideals are parallel with those of the Federation, and our training and our duties have given us a key position in the industry, but the key is seldom turned. We do not ask for patronage—we are not humble.

"With no strings attached we ask that our unique knowledge and understanding of the industry and it's problems is used by the industry to further the prosperity and smooth running of all its branches."

Mr. Forse went on to say that the members of the Association liked potting, and believed in the industry's future. They did not subscribe to the Association merely to get something in return, but felt that conjointly members could be of service to each other and enlarge their knowledge, and hence efficiency, as managers. He concluded by saying:

"We are human of course, and we try to do as well for ourselves as is possible, but always in our minds we have the

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welfare of our own firms and of all firms. We have enough sense to know that a prosperous industry means good salaries and good chances of promotion, and we know that the interest we show in our jobs is in the interest of our directors, who in their turn comprise the Pottery Manufacturers' Federation.

"It is unfortunate, perhaps, that on the rare occasions on which we have officially met representatives of the Federation, it has been to discuss matters connected with salaries. It is true that salaries and conditions of employment are one of our concerns, but they are only two aspects of our many activities.

"We would like to see all sections of the industry making full use of us on all committees which deal with matters of interest to and concerning, the whole field of ceramics. No committee can be truly representative unless we are present. We feel that the service we have given, and give daily to our firms, has earned for us the right to be officially represented.

"Your members, Mr. Goddard, daily show their confidence in us. They are the directors for whom we work, whose interests we guard, whose factories we run and whose balance sheets depend in no small degree on the efforts we make and on the loyality we show. Is it not right and logical that this confidence so readily shown to us as individuals should also be extended to us as an official body The British Pottery Managers' and Officials' Association?

"We, too, have confidence in the manufacturers. There must be few industries with directors having so much practical and technical knowledge of the industry they control. Master potters are not a dying race. They are still being bred and trained; and it is our own members who do much of the training.

"Your members are often to be seen at the open lectures held by us each month, and they are very welcome guests. We meet them too at the lectures organised by the Ceramic Society and at those excellent meetings held by Dr. Green and his boys at Penkhull, and as we eat our bun in Dr. Arnold's Snappy Snack Bar before the meetings start, we note that they, like us, are talking shop.

"We find that men with names famous in this district, and not unknown outside it, treat us with courtesy and understanding, and are ready to listen as well as to talk to learn as well as to instruct and we respect and like them for it.

"It is these men who collectively form the Manufacturers' Federation, which I prefer to think of not as a group of impersonal firms represented by trade names, but rather as the individuals comprising those firms.

"I would apologise to Mr. Goddard if I have spoken about our Association as much as I have about his Federation, but we are interlocking pieces in the jig-saw of ceramics and we are joined by virtue of our common interest."

Mr. Goddard in replying to the toast, said that the Federation was alive to the value of the Association. He added, however, that although they might be individually interested, yet the Federation as a body, was quite different. The constitutions of the two organisations were different. The Managers' Association consisted of individual members, but membership of the Federation was not a personal matter. He pointed out that it was the firm who employed and therefore the firm must be consulted, and it followed that the Association could not be called in officially.

He contended that the livelihood of the industry depended upon quality which, in turn, meant efficiency, and said that the manufacturers had been described as reluctant to adopt new methods, but pointed out that in the last 10 years they had spent considerable sums of money in modernisation, whilst efforts in this direction were still being made. They were alive to both inside and outside competition, and to those who queried prices he suggested that prices were never high enough. In 1939 the industry had 63,000 operatives with 20 per cent. unemployed. Today it had 56,000 and no unemployed. Today's turnover was £30,000,000 per annum, which was greater than in 1938.

Mr. Goddard said that the Federation was accepted by the Government in matters appertaining to the employing side of the industry, and the Federation was therefore the body for considerations on wage claims, and finally he pointed out that the Federation could never function usefully without its officials, and in this respect, paid tribute to Mr. Wentworth Shields.

The toast to the guests was proposed by **Mr. A. Clough**, a member of the Executive Committee of the British Pottery Managers' and Officials' Association. In a humorous speech he expressed agreement with Mr. Forse but said that he was a pottery manager employed by himself, who owned his own firm. He said that the Association must build up its own importance.

Dr. A. T. Green, O.B.E., D.Sc., F.R.I.C., Director of the British Ceramic Research Association replied on behalf of the guests. He made the point that it was useless to consider that Britain was the only country which could make pottery. Equal quality could be obtained elsewhere and, more important, the

home countries tended to produce for their own individual requirements. He emphasised that individuality was obtainable from research which led to increased efficiency of manufacture which, in turn, was achieved by having an increased knowledge of the raw materials used.

The toast to the British Pottery Managers' and Officials' Association was proposed by **Mr. J. E. Hartill,** managing director of Mintons Ltd., who had some amusing and pointed remarks to pass upon the qualities of directors and their cigars.

The response was made by **Mr. D. N. S. Salt,** President of the British Pottery Managers' and Officials' Association. He thanked Mr. Hartill for having "spoken the truth about pottery directors rather than embarrassing everyone by speaking the truth about pottery managers." He said:

"It is indeed a great pleasure at any time to contemplate directors in the abstract: a pleasure which can only be equalled by contemplating them in the concrete!"

Mr. Salt mentioned the 34 years since the Association began and he said that "In the Association's early days the 'practical' versus 'theory' argument was developing nicely. In those days the 'practical' man said quite definitely what would happen and the 'theorist' said what ought to have happened. Now only the 'theorists' are left and they use the label 'practical.'" He said—"Dr. Green and his merry men now publish a 40-page documentary telling us what has happened—whilst the former 'practical men' tell us what ought to have happened."

On a factual basis, Mr. Salt contended that the future was left very much in the hands of the managers who must produce pottery ware, and pottery ware at a cheaper price. He begged that skill and craftsmanship should be retained, particularly on the diverse shapes and patterns which hallmark British pottery, but work was necessary to study processes, shop layouts and increased productivity. On the question of mechanisation he felt that its acid test was quality. If a machine-produced article was as good as or better than the hand-made article, and if it was as flexible in quantity and variety of production, then it would be industrial suicide to ignore it. He said: "Such machines are being developed." He continued further—"If we can stimulate a quality competition between handcraft and machine then we will have done something really worth while." He stressed the success of the pottery industry as any other as being in a direct proportion to the strength of the leadership given by management—a leadership based on personal integrity, knowledge and experience. He voiced the aspirations of the Association as:

1. For our industry — Supremacy, through quality and productivity.
2. For our employers—Loyalty, without servility.
3. For our workers—Justice, without condescension.
4. For ourselves — Improved status, through knowledge, experience, and ability.

Councillor C. E. P. Stott, J.P., and Mr. W. B. Stoddard, J.P., watch the unloading of a pottery furnace at an Industrial Exhibition held in connection with the recent Preston Guild Merchant celebrations

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THE THEORY AND PRACTICE OF VITREOUS ENAMELLING

J. H. Gray. Industrial Newspapers Ltd., London. Price: 10/6d.

THE author, Mr. J. H. Gray, A.I.Mech.E., is well known to most in the vitreous enamelling field, and it is pleasing that he has thought fit to carry on the work of his father, Mr. J. F. Gray, who died in 1949 and whose death "robbed the industry and the Institute of a staunch and popular champion."

In about 40 pages the author deals from the student point of view with a short history of the craft followed by notes on frits, milling practice, sheet iron quality, the design, characteristics, the preparation, groundcoat application, drying, fusing and inspection. In Part 2, reference is made to sheet iron cover coating, brushing and transferring, castings for wet process enamelling, the preparation of castings, the processing of castings and final inspection. Part 3 deals with colour matching, the various types of finish, the control of processing, a description of the enamelling furnaces and their control. Part 4 covers de-enamelling, the suspension of enamels, frit formulæ, enamelling faults and the care of furnaces. In the end there comes a glossary of terms, production hints and definition tables. The Appendix outlines some typical vitreous enamelling lay-outs.

All the proceeds from the sale of the book are being donated by the author to the funds of the Institute of Vitreous Enamellers, to be used in furthering its aims for the benefit of the enamelling industry.

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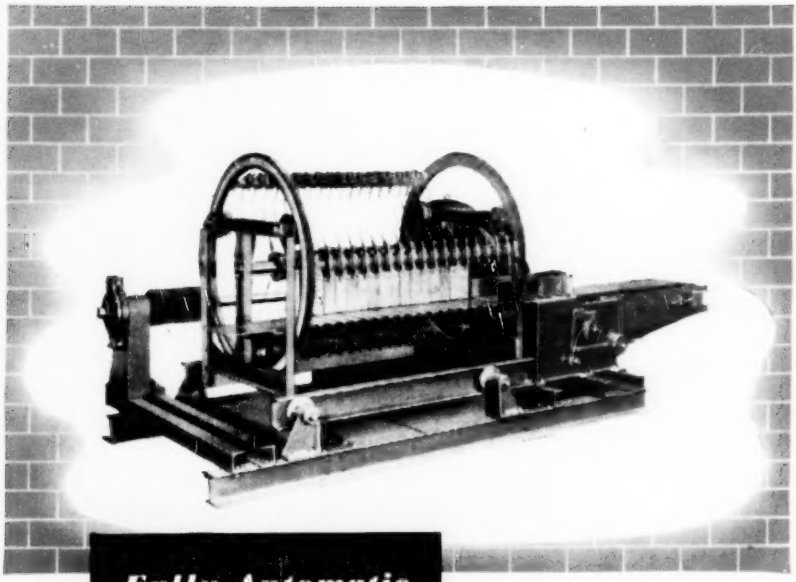

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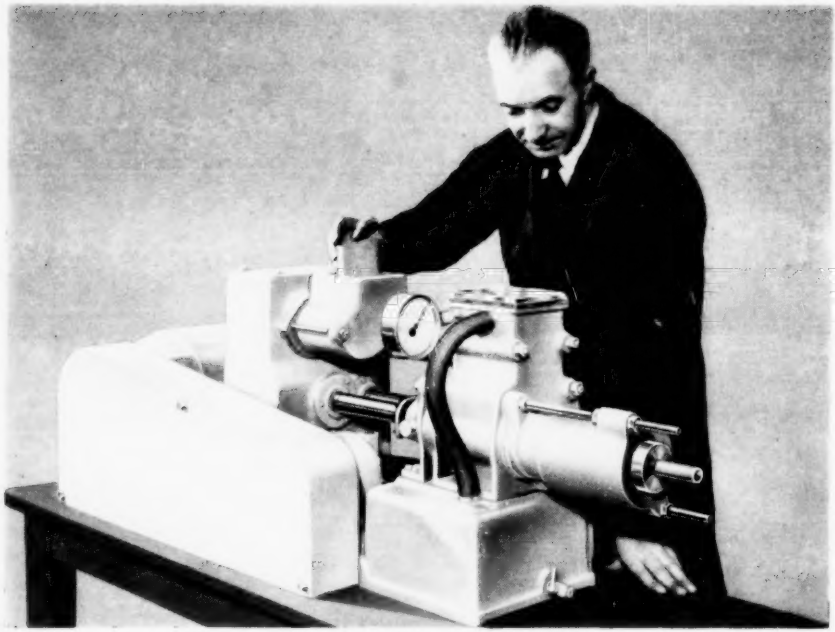

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